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A Continuing Bibliography with Indexes

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NASA SP-7037(216)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 216)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in July 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 505 reports, journal articles and other documents originally announced in July 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER **N87-10039*#** National Aeronautics and Space Administration. CORPORATE SOURCE
Langley Research Center, Hampton, Va.
TITLE **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION** PUBLICATION DATE
AUTHOR D. R. SATRAN Oct. 1986 60 p AVAILABILITY SOURCE
REPORT NUMBERS (NASA-TP-2623; L-15929; NAS 1.60:2623) Avail: NTIS HC
PRICE CODE A04/MF A01 CSCL 01A COSATI CODE

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER **A87-11487*** National Aeronautics and Space Administration.
Ames Research Center, Moffett Field, Calif.
COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION TITLE
AUTHORS D. DEGANI and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) AUTHOR'S AFFILIATION
JOURNAL TITLE Journal of Computational Physics (ISSN 0021-9991), vol. 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation.

T.K.

01

AERONAUTICS (GENERAL)

A87-31451
DIGITAL AVIONICS SYSTEMS CONFERENCE, 7TH, FORT WORTH, TX, OCT. 13-16, 1986, PROCEEDINGS
Conference sponsored by IEEE and AIAA. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 831 p. For individual items see A87-31452 to A87-31549.

Various papers on digital avionics systems are presented. The general topics addressed include: software management; standard modular avionics, communication, navigation, and identification; space systems technology; rotorcraft avionics; advanced control/display technology for crew systems; software development and evaluation tools; data buses in subsystem interconnections; digital map techniques; commercial transportation avionics/collision avoidance systems; and human factors in crew systems. Also considered are: software verification and quality assurance; sensor signal and data processing; design for testability in system concept; fiber optics; Ada; fault tolerance and reconfigurability in system concept; digital flight controls; data link system applications; artificial intelligence and expert systems; advanced digital integrated circuits technology, design, and testability; integrated flight/propulsion control; and general aviation avionics. C.D.

A87-31543*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DIGITAL AVIONICS SYSTEMS - OVERVIEW OF FAA/NASA/INDUSTRY-WIDE BRIEFING
WILLIAM E. LARSEN (NASA, Ames Research Center; FAA, Moffett Field, CA) and ANTHONY CARRO (FAA, Technical Center, Atlantic City, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 731-737.

The effects of incorporating digital technology into the design of aircraft on the airworthiness criteria and certification procedures for aircraft are investigated. FAA research programs aimed at providing data for the functional assessment of aircraft which use digital systems for avionics and flight control functions are discussed. The need to establish testing, assurance assessment, and configuration management technologies to insure the reliability of digital systems is discussed; consideration is given to design verification, system performance/robustness, and validation technology. I.F.

A87-31548
SYSTEM METHODS FOR AVIONICS DEVELOPMENT AND INTEGRATION
PAUL EBNER GARTZ (Boeing Commercial Airplane Co., Seattle, WA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 784-792. refs

A set of life cycle methods were developed in 1980 and 1981 and used in the later phases of the 757/767 airplane programs. They have been used as a framework to establish and guide the introduction of a wide use of similar methods for the future avionics of Boeing's next airplane, the 7J7. The methods were designed to improve communication of the system's requirements, architecture, and implementation to a wide group of interested parties. A major aspect of these methods is that they were designed to be used for systems in general not just software systems. This paper describes the background, goals, and objectives leading to the need for systems engineering methods. It also describes the methods and gives an example of their use. Author

A87-31618#
FAA - AN AGENCY BESEIGED. II - TECHNOLOGY FOR AIR SAFETY
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 25, March 1987, p. 36-39.

FAA programs to reduce the risk of aircraft collisions are discussed. The primary thrusts are Traffic Alert and Collision Avoidance Systems (TCAS) on commercial transport aircraft and the installation of automated en route air traffic control (AERA) equipment. TCAS interrogates all Mode C transponders in the area and computes altitude and position data from the return signals. TCAS system will localize other aircraft to within 12 deg, and TCAS III is to provide positioning to within 2 deg. Private and commercial organizations are resisting a mandatory TCAS II because of low positioning accuracy and the additional costs of upgrades to TCAS III. The phased approach to the installation of the AERA system, ending with computer-generated clearances and look-ahead capabilities for ATC personnel to project the results of flight route decisions, is summarized. M.S.K.

A87-31619#
ARE GENERAL AVIATION MODIFIERS NEEDED?
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 25, March 1987, p. 40-42.

Various ways in which third-party research companies are developing modifications which increase the efficiency and performance of general aviation aircraft manufactured by other companies are explored. The industry has appeared because of the inability or unwillingness of small aircraft manufacturers to maintain substantial R&D programs, a situation which retards the improvement of aircraft designs through innovations. Several modifications introduced to existing, series-produced aircraft by the Raisbeck Engineering Company are noted. The modifications include a new leading-edge contour for the King Air 200 to reduce drag and takeoff pitch-up, for-bladed high-lift propellers, and a ram-air recovery system. M.S.K.

A87-32071
HELIX - A CAUSAL MODEL-BASED DIAGNOSTIC EXPERT SYSTEM
DAN W. SIMMONS, THOMAS P. HAMILTON (United Technologies Research Center, East Hartford, CT), and RAYMOND G. CARLSON (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Jan. 1987, p. 19-25. refs

An expert system for diagnosis has been developed which addresses the problem of capturing an expert pilot's ability to reason qualitatively about the causal relationships in a physical system. This system designated HELIX (HELIcopter eXpert), performs causal reasoning to diagnose faults in a twin-engine gas

turbine helicopter power train from instrument readings. At the heart of the HELIX program is a causal model which represents the important components in the power train and the ways in which these components interact to power the aircraft. The approach represents a promising technique for automating the qualitative causal reasoning required to model the expert pilot and, hence, may form the basis for extensive automation in an advanced cockpit configuration. This paper describes HELIX qualitative causal reasoning techniques and highlights the system's capabilities. Author

A87-32482

PREDICTION OF HE GAS LIFT IN A PLASTIC BALLOON

JUN NISHIMURA and TAKAMASA YAMAGAMI (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1537-1541.

A change of He gas temperature in its container during the filling of a balloon is estimated by assuming a simple model of heat transfer. By adjusting a parameter in this model, the prediction agrees quite well with data observed for 14 balloons of various initial pressures and temperatures of He gas. The lift of He gas inside the balloon is estimated within a fraction of one percent of gross lift if this prediction is used. A discussion is also made on the accuracy of the method adopted now at balloon facilities in U.S. and Australia, referring to this prediction. Author

A87-32600

THE MARKET POTENTIAL OF FUTURE SUPERSONIC AIRCRAFT

RAYMOND A. AUSROTAS (MIT, Cambridge, MA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p. refs
(SAE PAPER 861684)

The X-31 hypersonic vehicle being studied by the U.S. is expected to run $3-20 billion in total development costs before it flies near the turn of the century. The factors which control the economical use of such an aircraft by commercial operators, e.g., the number of passengers and the speed at which the aerospaceplane flies, are examined. The X-31 program was initiated to cut by at least a third the travel time to Pacific rim countries, which are expected to become increasingly more important economically in the next two decades. Similarities between projected demands for aerospaceplane services and those made for the Concorde to garner government financing of that aircraft are discussed, noting that the Concorde will never become economical to operate. However, the aerospace plane will be ready for production when the current generation of large, long range transport aircraft are ready for replacement. M.S.K.

A87-32601

SUPERSONIC CRUISE TECHNOLOGY ROADMAP

ROGER L. WINBLADE SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p.
(SAE PAPER 861685)

One of the three National Aeronautical R&D Goals of the President's Office of Science and Technology Policy was the attainment of long-distance supersonic cruise capability. NASA was asked to lead the development of a 'technology roadmap' for this goal. The roadmap identified critical technology elements that need to be pursued and provided an outline of the most effective approach for achieving technology readiness. The effort, briefly addressed in this paper, was intended to provide a first top level framework to support the preparation of more detailed technical plans through the combined efforts of private and public sectors of the aeronautics communicty. Author

A87-32602

HIGHER CRUISE SPEED COMMERCIAL AIRCRAFT EVOLUTION

A. J. ANDERSON (Boeing Commercial Airplane Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 41 p.
(SAE PAPER 861686)

The paper addresses the technology developments and business conditions necessary for launching subsonic commercial transports in today's business environment. The possibilities for a second-generation SST and the potential economic payoff using evolving technology are discussed. The evolution of the first-generation high speed commerical transports is reviewed by looking back at the Concorde and U.S. SST development activity. Then, the technical requirements and evolution necessary for a second-generation SST are reviewed and, finally, observations of technology challenges facing hypersonic commercial transportation are made. Author

A87-32604

MILITARY AIRCRAFT SYSTEM ENGINEERING

LEO MEHLER (Boeing Military Aircraft Co., Wichita, KS) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 11 p. refs
(SAE PAPER 861690)

The evolution of aerospace system engineering is summarized. Rigorous application to military aircraft is described. The concept of core system engineering is introduced. Recent developments and some innovations in the process are presented. A practical example is utilized to illustrate the core approach. Author

A87-32936

THE GLOBAL NATURE OF THE AIRCRAFT MANUFACTURING INDUSTRY

DONALD R. SEGNER (FAA, Office of Policy and International Aviation, Washington, DC) (Society of Experimental Test Pilots, Symposium, Washington, DC, Apr. 25, 1986) Cockpit (ISSN 0742-1508), Oct.-Dec. 1986, p. 4-9.

The effect of the international nature of the aircraft manufacturing industry on the FAA's certification procedures is examined. It is stated that European countries are becoming a dominant force in the aircraft industry and that they are developing aircraft jointly with other countries and receiving government subsidies. The need for U.S. involvement in multinational projects is discussed, and examples of successful multinational projects are provided. Consideration is given to FAA aircraft certification on the international level and bilateral airworthiness agreements. Examples revealing the problems encountered in creating bilateral airworthiness agreements and certifying internationally manufactured aircraft are presented. I.F.

A87-33136

ENCIRCLING THE EARTH

ROBIN BLECH Flight International (ISSN 0015-3710), vol. 131, Feb. 14, 1987, p. 40-43.

Dick Rutan and Jeana Yeager circumnavigated the globe in a nonstop flight of 216 hrs in December, 1986; the ultrahigh aspect ratio wing canard configuration airframe used was constructed entirely of fiber-reinforced polymer composites, and employed virtually all noncabin volumes defined by its monocoque structures as fuel tankage. An account is presently given of the numerous difficulties and uncertainties confronted by the crew, which included doubts as to fuel supply sufficiency, anoxia at high altitudes, a severe storm over Africa, a typhoon over the southwest Pacific, avoidance of Vietnamese air defenses, and general fatigue. Extensive use was made of lean air-fuel mixtures to extend range under appropriate circumstances. Primary navigation relied on GPS/VLF/Omega signals; difficulties were experienced with both HF and UHF communications. O.C.

A87-33424
CHANGING SCENE IN THE U.S. AIR TRANSPORTATION SYSTEM (LECTURE)
JOSEPH F. SUTTER (Boeing Commercial Airplane Co., Seattle, WA) New York, Wings Club, 1986, 32 p.

The author reviews developments in the U.S. air transportation system that occurred during his career with a major corporation in the industry. The aircraft programs discussed include the B-377 Stratocruiser, the 707 prototype, the 727 Trijet, the 737 Twin Jet, the SST and the 747 programs, and the Advanced Technology Aircraft. The current state of the U.S. aircraft industry is evaluated, stressing the need for more cooperation between manufacturers, airlines, governmental agencies, and other benefitting participants in order to maintain the quality of the U.S. air transportation system. C.D.

A87-33598#
THERMOPLASTIC COMPOSITE C-130 BELLY SKINS - DESIGN, MANUFACTURING, AND TEST
L. P. BECKERMAN, T. L. GREENE (Lockheed-Georgia Co., Marietta), and T. F. CHRISTIAN, JR. (USAF, Warner-Robins Air Logistics Center, Robins AFB, GA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 414-419.
(AIAA PAPER 87-0798)

This paper presents the C-130 Belly Skin Program. The objective of this program is the in-service evaluation of a graphite fiber reinforced thermoplastic panel installed on the belly of a USAF C-130 transport aircraft. The design, manufacturing, and structural verification tasks performed to develop the technology and to ensure the safety of the airplane are described. Author

A87-34647#
MATERIALS PACE ATF DESIGN
ALAN S. BROWN Aerospace America (ISSN 0740-722X), vol. 25, April 1987, p. 16-20, 22.

The USAF's next-generation Advanced Tactical Fighter (ATF) requires materials and structural technologies capable of supporting its supersonic cruise, 9-g maneuvering with full load, and radar invisibility design criteria; the ATF must, moreover, weigh only about 50,000 lbs. These goals will be met through the use of such state-of-the-art materials as metal-matrix composites, aluminum-lithium alloys, high temperature aluminum-iron alloys, and carbon-carbon composites, in addition to carbon fiber-reinforced thermoplastic matrix composites capable of withstanding the high temperatures associated with supersonic cruise. It is noted that carbon fibers have ideal radar pulse energy attenuation characteristics. O.C.

A87-34864
HEALTH AND USAGE MONITORING OF HELICOPTER MECHANICAL SYSTEMS
D. G. ASTRIDGE (Westland Helicopters, Ltd., Yeovil, England) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 341-357. refs

The present technology development status evaluation of monitoring techniques, sensors and data processing systems for helicopter engines, transmissions, and rotor systems gives attention to examples of the application of simple 'expert system' computation techniques for the enhancement of monitoring system capability. While greater benefits are obtainable through the design of comprehensive onboard processing systems for new helicopters, it is noted that substantial airworthiness, readiness, and operating cost improvements may be obtained through retrofitting of such systems aboard existing helicopters. Each monitoring parameter requires the establishment of clear numerical limits for mission and maintenance alerts and rejection criteria. O.C.

A87-35073
AIRCRAFT WITHOUT AIRPORTS - THE TILT-ROTOR CONCEPT AND VTOL AVIATION (SEVENTY-FIFTH WILBUR AND ORVILLE WRIGHT LECTURE)
HANS MARK Aerospace (UK) (ISSN 0305-0831), vol. 14, March 1987, p. 9-16.

A report on the history, status and propable future of tilt-rotor VTOL aircraft is presented. Among the aircraft discussed are the Ryan XV-5A, the British Aerospace XV-6A Kestrel, the Bell XV-3, the LTV SC-142, and the Bell XV-15. The advent of the 'smart' Exocet missile that force ships to stand off shore targets beyond the normal range of helicopters is making the concept more attractive. An advanced tilt-rotor, the V-22 Osprey, with a total gross weight of about 40,000 lb and able to carry 24 fully armed assault troops is discussed. In future applications, the Bell D326 Clipper is envisioned; it is a commercial tilt-rotor design proposal, derived from the V-22. D.H.

A87-35176
DFVLR, ANNUAL REPORT 1985 [DFVLR, JAHRESBERICHT 1985]
Cologne, West Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, 1986, 123 p. In German. For individual items see A87-35177 to A87-35185.

The activities of the West German aerospace research agency DFVLR during 1985, its organizational structure, and its personnel and economic status are surveyed and illustrated with diagrams, drawings, and photographs. Reviews are presented for the main research fields ATC, aircraft technology, turbine propulsion and turbomachines, nonnuclear energy systems, satellite communication and navigation, remote sensing, space systems, and advanced technologies and technology transfer. Also included are more specific technical reports regarding integrated navigation, communication, and airspace-surveillance systems; laser gyros; Arall hybrid composites; propfan engines; the Hermes heliostat and receiver measuring system; the German Spacelab mission D1; the MIDAS image-processing system for remote sensing; and an RF-excited 1-kW CO2 laser for materials processing. T.K.

N87-20173# Office of Naval Research, London (England).
A SURVEY OF MILITARY AEROSPACE SYSTEMS TECHNOLOGY DEVELOPMENTS IN WESTERN EUROPE AND THE MIDDLE EAST
L. L. COBURN 17 Oct. 1986 48 p
(AD-A175635; ONRL-R-6-86) Avail: NTIS HC A03/MF A01 CSCL 01C

Military aerospace system developments and defense aerospace research/development manufacturing are discussed in this report. The military aerospace systems include fighter aircraft, large aircraft, helicopters, air weapons, and space system. GRA

N87-20174# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
THE REPAIR OF AIRCRAFT STRUCTURES INVOLVING COMPOSITE MATERIALS
Loughton, England Oct. 1986 240 p In ENGLISH and FRENCH Meeting held in Oslo, Norway, 14-16 Apr. 1986
(AGARD-CP-402; ISBN-92-835-0400-3) Avail: NTIS HC A11/MF A01

Modern combat aircraft are making increasing use of composite materials in both primary and secondary structures, and the need for repair schemes which involve a mixture of composite and metallic materials is no longer exceptional. At its sixty-second meeting, the Structures and Materials Panel held a conference of Specialists, the aim of which was to share experiences of repairs involving composites and structures now in service. A further aim was to highlight the demand for the development of innovative times and increase repair capabilities under all conditions of service but also make for greater standardization.

N87-20175# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
REPAIR PROCEDURES FOR COMPOSITE PARTS ON THE ALPHA JET
TH. THIELE *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 7 p Oct. 1986
Avail: NTIS HC A11/MF A01

A survey is given of activities to develop repair procedures for the composite parts of the alpha jet. The complete program was divided into two parts: the first part covered the repair and test of specimen; the second part the repair and test of a full scale speed brake. Author

N87-20177# Lockheed-California Co., Burbank.
DEVELOPMENT OF FIELD LEVEL REPAIRS FOR COMPOSITE STRUCTURES
ROBERT H. STONE *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 12 p Oct. 1986
Avail: NTIS HC A11/MF A01

Bolted and bonded field-level repairs have been developed, fabricated and tested at Lockheed-California Company for several recent contract and independent research programs. Bolted repairs are particularly well adapted to field repair situations. Bolted aluminum repair concepts have been developed and verified under a NASA sponsored program for an L-1011 composite inboard aileron, which is now in flight-service evaluation. Special drilling, machining, fastener installation and sealing procedures were developed for these repairs. Bolted repairs were also developed and validated under a Naval Air Development Center (NADC) sponsored program. These included various configurations of aluminum and titanium patches using blind fasteners, with drilling and installation procedures representative of field conditions including lack of back-side access. Repair specimens were tested in tension and compression, and the patches restored design strength levels to the damaged composite. Bonded field repairs require adhesives with room temperature storability in addition to the other structural/environmental requirements. Screening tests were run on various film and two-part adhesives. A two-part adhesive, developed by NADC and now commercially available, had the best combination of properties for field repairs. Other tests related to bonded field repairs determined that 177 C (350 F) curing film adhesives have several months' storability at room temperature, and verified prebond storability of titanium surface treatments for use in bonded repair kits. Author

N87-20179# Societe Nationale Industrielle Aerospatiale, Marignane (France). Advanced Engineering Dept.
REPAIR OF HELICOPTER COMPOSITE STRUCTURE TECHNIQUES AND SUBSTANTIATIONS
MANUEL TORRES and BERNARD PLISSONNEAU *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 21 p Oct. 1986
Avail: NTIS HC A11/MF A01

The advantages of composite materials are now well known and have been widely demonstrated. Lighter weight, lower cost, shorter manufacturing cycles, damage tolerance, etc. are some of the advantages. As a result, composite materials are increasingly used in helicopters. Helicopter designs have made extensive use of composites for over twenty years. Composite rotor blades date from 1970. More recently, major programs have been undertaken to produce the future generation of helicopters with a totally composite fuselage. The increasing number of composite items in the aircraft structure raises the problem of damage and repair. This concern is further justified by the relatively high damage probability of a helicopter that may be operated in severe environmental conditions. The repair philosophy engages the responsibility of the aircraft manufacturer as well as the operator. The manufacturer must develop and substantiate repair methods that are as simple as possible. The operator must be equipped with suitable inspection and repair facilities. These repairs must ensure an adequate safety level for the remaining helicopter's service life. They must be suitable for the nature of the damage and the type of part involved. They must be as easy as possible to implement and require minimal special tools and expertise, and the repair cost must remain well below the price of new replacement parts. Author

N87-20181# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Stress Office.
COMPOSITE REPAIR OF COCURED J-STIFFENED PANELS: DESIGN AND TEST VERIFICATION
GEORG GUENTHER and LUDWIG LEMMER *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 19 p Oct. 1986
Avail: NTIS HC A11/MF A01

An increasing percentage of military aircraft fuselage and wing structures are being replaced by cocured integrated carbon fiber composite (CFC) structures. The probability of damage in day-to-day operation is increased, since most of the structure is located on the aircraft surface. The most common field of application for cocured stiffeners are thin panels critical to buckling under shear and/or compression loading and fuselage frames subject to bending. Bonded repair methods for two maintenance levels (depot and field) have been developed and tested using representative components. For the stiffened panels both repair methods (field and depot) fulfilled structural requirements and proved their durability in the fatigue tests. Test results of the stiffened skin elements showed that cocured fuselage structures with complex geometries are repairable without reduction in strength and stiffness. Tests performed after artificial ageing of the repaired structure proved their reliability in the environment. Author

N87-20182# Royal Aircraft Establishment, Farnborough (England).
EFFECT OF ADHESIVE BONDING VARIABLES ON THE PERFORMANCE OF BONDED CFRP PATCH REPAIRS OF METALLIC STRUCTURES
P. POOLE, M. H. STONE, G. R. SUTTON, and R. N. WILSON *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 21 p Oct. 1986
Avail: NTIS HC A11/MF A01

The literature is briefly reviewed and limitations of the existing experimental data on the performance of bonded carbon fiber reinforced plastics (CFRP) patches are indicated. Earlier work from the Royal Aircraft Establishment is summarized, showing the importance of patch size and crack growth conditions prior to patching. Fatigue data for center-cracked, patched aluminum alloy thin sheets (7075-T76) are then presented. These show that: adhesive layer stiffness had only a moderate effect; differential contraction stresses had much less effect than predicted; and neither variations in surface treatment of the aluminum alloy before bonding nor exposure of the patched sheet to warm/moist conditions had any substantial effect on crack rates. Bond durability wedge and peel tests did show marked effects of alloy pretreatments. Explanations are advanced for the lack of effect of moisture and alloy pretreatment on the alloy-adhesive bonds of the patched sheets. Author

N87-20183# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aeronautical Systems Div.
COMPOSITE REPAIR OF CRACKED ALUMINUM STRUCTURE
LARRY G. KELLY *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 6 p Oct. 1986
Avail: NTIS HC A11/MF A01

The use of bonded composite patches for repair of a wide range of typical fatigue cracked and otherwise damaged aluminum structural panels is discussed. Experimental data on stress intensity and crack growth characteristics were obtained to evaluate the advantages of such repairs. A range of metal thickness and patch parameters (thickness, orientation, bonding temperature) were tested. Edge cracked 4 inch by 18 inch 2024T3 aluminum panels were patched and fatigue behavior evaluated under constant amplitude and the Falstaff flight spectrum loading. The results showed panel thickness and fatigue test load spectrum to be important parameters. Present repair procedures for cracked

aluminum aircraft structures call for bolted on metal patches. Advanced composite material bonded to such damaged structures offers the advantage of increased fatigue life. To quantify this advantage a test program was conducted with boron/epoxy patches on cracked aluminum panels. The panels were subjected to both constant amplitude and flight spectrum loads. The objective was to establish the reduction in stress intensity and thus reduced crack growth rate achieved through the use of room temperature and 250 F cured adhesive bonded patches. The pertinent parameters evaluated were aluminum thickness, patch area, and ply orientation. Dramatic improvements in fatigue life were achieved up to 20 times extended lifetimes for 1/16 inch repaired aluminum panels having an initial .34 inch induced crack. Author

N87-20184# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

DAMAGE REPAIR OF IN-SERVICE COMPOSITE STRUCTURES: APPLICATION TO THE MIRAGE 2000 [REPARATION DE DOMMAGES EN SERVICE DES STRUCTURES COMPOSITES. APPLICATION AU MIRAGE 2000]

DANIEL CHAUMETTE and FRANCOISE HENRIOT *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 10 p Oct. 1986 In FRENCH; ENGLISH summary

Avail: NTIS HC A11/MF A01

A summary is given of the 15 years experience AMD/BA has had in the field of composite structures repair, and the application to the case of the Mirage 2000. AMD/BA has developed repairs using a boron fiber dry fabric impregnated and bonded in situ on aluminum structures. These repairs have been the subject of tests, and of such practical applications as local reinforcements on the Mercure airliner. Since 1978 a large number of carbon fiber ailerons have been put in service on the fighter aircraft Mirage F1 and on the Falcon 50 business jet. Repair procedures have been developed for these elements. These elements have been troublefree up to now. Author

N87-20185# Societe de Construction des Avions Hurel-Dubois, Paris (France).

COMPOSITE STRUCTURE REPAIRS CARRIED OUT ACCORDING TO AERONAUTICAL TECHNIQUES [REPARATIONS DE STRUCTURES COMPOSITES REALISEES SELON LES TECHNIQUES AERONAUTIQUES]

JEAN-ALAIN JOUAN *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 13 p Oct. 1986 In FRENCH

Avail: NTIS HC A11/MF A01

Advanced composite materials (aramide, carbon, honeycomb) initially utilized in aircraft structures are seeing their domain of application extended to other sectors. The experiences of Hurel-Dubois with two specific composite material applications, frames for the Formula 1 racing car and structures for transoceanic racing catamarans, are discussed with reference to damage repair and the restoration of structural integrity. The various types of in-service damage are outlined and the materials and procedures for repair are described. Author

N87-20186# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

COMPOSITE REPAIR TECHNIQUES FOR J-STIFFENED COMPOSITE FUSELAGE STRUCTURES

K. LEDWA *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 11 p Oct. 1986

Avail: NTIS HC A11/MF A01

The next generation of lightweight military aircraft will feature an essentially increased application of carbon fiber reinforced plastics (CFRP) to primary structure including fuselage side skins. Mainly for cost and weight reasons they will be large size integrally stiffened components cocured in a single shot operation. In order to avoid a costly replacement of the entire side skin in case of damage, adjusted repair techniques are required. Basic repair philosophies for field and depot level repairs using composite materials were defined and proved by two different types of test specimen. Specially designed flat panels with a 50 mm diameter hole penetrating skin and stiffener were followed by single curved side skin elements damaged by a destructive qualification test. Both types were repaired using different methods and finally destructive tested. The test results showed that the restoration of part stiffness and sufficient strength after repair can successfully be realized. Manufacturing problems were recognized concerning material choice and cure cycles at elevated temperatures and regarding the nondestructive inspection of applied repair patches. Author

N87-20187# Aeronautical Research Labs., Melbourne (Australia).

FIBRE COMPOSITE REPAIR OF CRACKED METALLIC AIRCRAFT COMPONENTS: PRACTICAL AND BASIC ASPECTS

A. A. BAKER *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 21 p Oct. 1986

Avail: NTIS HC A11/MF A01

Crack patching, the use of advanced fiber composite patches (such as boron/epoxy or graphite/epoxy) bonded with structural film adhesives to repair cracks in metallic aircraft components, is a significant development in aircraft maintenance technology, offering many advantages over conventional repair procedures based on metallic patches and mechanical fasteners. Selected theoretical and experimental aspects of Australian work on this topic are previewed. A preliminary design approach for estimating the minimum thickness patch that could be employed in a given repair situation is described. Finally, the case study on the repair to the wing skin of Mirage 3 aircraft is given. Aspects discussed include evaluation of minimum cure and surface-treatment conditions for adhesive bonding in repair situations; potential thermal and residual stress problems resulting from patching; studies on overlap joints representing repairs and crack propagation behavior in patched panels. Author

N87-20188# Naval Air Development Center, Warminster, Pa.

COMPOSITE REPAIR MATERIAL AND DESIGN DEVELOPMENT EFFORTS

R. C. COCHRAN, T. M. DONNELLAN, E. L. ROSENZWEIG, and R. E. TRABOCCO *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 13 p Oct. 1986

Avail: NTIS HC A11/MF A01

Recent developments in the area of bonded and bolted composite repair are discussed. An ideal resin or adhesive for field repair would have the following characteristics: ambient storage, low temperature cure, short time cure, elevated temperature and moisture resistance, and vacuum processing. Two approaches were used to achieve resin formulations for repair patches which will meet these requirements. The first method utilizes chemically hindred diamines as curing agents for epoxy resins. The second method involves isolation of the curing agents from the epoxy resin by phase separation. In the area of adhesives for field repair of composites, a two-part paste adhesive has been developed. The adhesive meets all of the program requirements and can be used with various repair materials. The design of bolted repairs for composite structures is discussed. A simplified design has been established which uses standard plate thicknesses, bolt sizes and spacing. Several patch shapes have been tested and found to restore design ultimate strains. Author

N87-20189# McDonnell Aircraft Co., St. Louis, Mo.

BATTLE DAMAGE REPAIR OF COMPOSITE STRUCTURES

THOMAS V. HINKLE, JACK VANES, and CHARLES L. RAMSEY (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.) *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 11 p Oct. 1986

Avail: NTIS HC A11/MF A01

Concepts and procedures for the rapid repair of battle-damaged composite structures are discussed. The damage consists of elongated or concentrated penetrations of solid wing skins and of honeycomb empennage. The size of the damage, in conjunction with the strength-critical nature of these structures, requires structural repairs in order to restore a strength capability commensurate with the maximum expected flight loads and service temperatures. Guidelines for these repairs are based on the USAF

concept of operation for aircraft battle damage repair. Structural tests are being conducted to validate repair designs. Damage simulation, repair design, damage cleanup, repair fabrication, and available test results are reported. Author

N87-20190# Army Materials Technology Lab., Watertown, Mass.
UNCONVENTIONAL APPROACHES TO FIELD REPAIR
STANLEY E. WENTWORTH, MICHAEL S. SENNETT, and JOHN W. GIBSON (Southern Research Inst., Birmingham, Ala.) *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 8 p Oct. 1986
Avail: NTIS HC A11/MF A01

Field repair of composites presents special problems for the Army where the repair might literally be performed in a field or other remote location. In such a situation, access to electric power both for refrigeration to preserve reactive resin systems and for heating to cure the patch, is severely limited. In order to circumvent these problems, we have investigated some novel approaches to the packaging and curing of composite patches. One approach involves a self-contained kit in which all of the patch components including the reinforcement are separate from one another until the patch is needed, at which time they are combined in the proper ratio by means of a simple operation. Shelf-life for such a system, even without refrigeration is thus indefinite. Another approach makes use of optical fibers to carry light energy into the interior of an otherwise opaque graphite fiber-reinforced patch thereby permitting the use of a photochemically curable matrix resin. Initial efforts to implement these approaches, some of the difficulties encountered, and current attempts to circumvent them are discussed. Some new approaches are also outlined. Author

N87-20191# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PATCH REPAIR OF CORRODED AIRCRAFT SKIN AREAS
W. G. J. THART and R. J. H. WANHILL *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 8 p Oct. 1986 Sponsored by the Royal Netherlands Air Force
Avail: NTIS HC A11/MF A01

Environmental conditions in Europe are conducive to corrosion attack of aircraft structures. In military aircraft, corrosion problems occur especially at countersunk fastener holes. The corrosion is generally removed by grinding. A limited amount of material removal is specified by the aircraft manufacturers, but it is sometimes necessary to exceed these limits. When this happens a repair is necessary to allow continued operation. An investigation of the effectiveness of bonded patch repairs was carried out. The patch materials were aluminum alloy sheet and aramid fiber reinforced composite prepreg. A cold curing acrylic based adhesive was used for bonding. Specimens with simulated patch repairs were subjected to both constant amplitude and flight simulation fatigue testing under various environmental conditions. The results indicated that bonded patches are potentially very good repairs for areas weakened by corrosion and its removal. Author

N87-20192# British Airways, Middlesex (England).
BRITISH AIRWAYS EXPERIENCE WITH COMPOSITE REPAIRS
K. B. ARMSTRONG *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 12 p Oct. 1986
Avail: NTIS HC A11/MF A01

British Airways experience with composite repairs since 1970 is discussed. The use of composite materials to repair metal structures such as Concorde wing leading edges is discussed. Repair of composite parts from Radomes starting in 1970, through B.747 body fairing and floor panels, to the repair of carbon fiber composite control surfaces and access doors on the B.757 is covered. Most of the repairs have used cold-setting resins (with heat lamp assisted curing) but some hot-setting adhesives and pre-pregs have been used. Effort is being made to develop techniques to facilitate the use of hot-setting adhesives. More information will be sought on diffusion and solubility coefficients of all types of adhesives to aid selection and improve the durability of repairs. Author

N87-20954 Civil Aviation Authority, London (England).
LIGHT AIRCRAFT MAINTENANCE. GENERAL GUIDANCE ON IMPLEMENTATION OF THE LIGHT AIRCRAFT MAINTENANCE SCHEME (LAMS), FOR AIRCRAFT NOT EXCEEDING 2730 KG MTWA, WITH A CERTIFICATE OF AIRWORTHINESS IN THE TRANSPORT, AERIAL WORK OR PRIVATE CATEGORY
May 1986 44 p
(CAP-520; ISBN-0-86039-284-8; ETN-87-99501) Avail: Issuing Activity

Owner's and operator's responsibilities in light aircraft maintenance; approval of organizations to carry out maintenance checks and to recommend renewal of certificates of airworthiness; maintenance schedules; log books; pilot maintenance; airworthiness flight tests; and engineering support arrangements for holders of Air Operators' Certificates are described. ESA

N87-20957# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Net Shape Technology in Aerospace Structures.
NET SHAPE TECHNOLOGY IN AEROSPACE STRUCTURES. VOLUME 1 Final Report, 1984 - 1986
MORRIS A. STEINBERG Nov. 1986 117 p
(Contract F49620-85-C-0107)
(AD-A176508) Avail: NTIS HC A06/MF A01 CSCL 13H

This report is in four volumes. Volume 1 is the committee's assessment of the state of net shape technology for aerospace applications based on briefings and discussion at the workshops. This report is an assessment of current and possible applications of net shape technologies by the Air Force, including: precision forging of alloys, powder metallurgy, structural ceramics, superplastic forming, diffusion bonding, vapor deposited coatings, etc.; and composites, including organic matrix composites, metal matrix composites, ceramic and carbon matrix composites in the manufacture of aircraft components. It also includes road maps of research and development efforts in performance and manufacturing technologies and resource allocation. GRA

N87-20958# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Net Shape Technology in Aerospace Structures.
NET SHAPE TECHNOLOGY IN AEROSPACE STRUCTURES. VOLUME 2. APPENDIX. PRECISION FORGINGS IN AEROSPACE STRUCTURES. PRESENTATIONS OF A WORKSHOP HELD ON DECEMBER 3-5, 1984 IN OXNARD, CALIFORNIA Final Report, 1984 - 1986
MORRIS A. STEINBERG Dec. 1986 420 p Workshop held in Oxnard, Calif., 3-5 Dec. 1984
(Contract F49620-85-C-0107)
(AD-A176509) Avail: NTIS HC A18/MF A01 CSCL 13H

This report is in four volumes. Papers presented by invited speakers at the workshops appear in Volume 2 (precision forging). This document is an appendix to Net Shape Technology in Aerospace Structures, Vol. 1. It contains 22 reports by representatives of industry, the military, and academe on precision forgings in aerospace structures. These reports were presented at a workshop held Dec. 3 to 5, 1984 in Oxnard, California. GRA

N87-20959# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Net Shape Technology in Aerospace Structures.
NET SHAPE TECHNOLOGY IN AEROSPACE STRUCTURES. VOLUME 3. APPENDIX. EMERGING NET SHAPE TECHNOLOGIES. PRESENTATIONS OF A WORKSHOP HELD ON MARCH 27-29, 1985 IN SANTA BARBARA, CALIFORNIA Final Report, 1984 - 1986
MORRIS A. STEINBERG Dec. 1986 526 p Workshop held in Santa Barbara, Calif., 27-29 Mar. 1985
(Contract F49620-85-C-0107)
(AD-A176510) Avail: NTIS HC A23/MF A01 CSCL 13H

This report is in four volumes. Papers presented by invited speakers at the workshops appear in Volume 3 (emerging technologies). This document is an appendix to Net Shape

Technology in Aerospace Structures, Vol. 1. It contains 30 reports by representatives of industry on emerging net shape technologies for the fabrication of aerospace parts. Technologies include: powder metallurgy, coatings, superplastic forming/diffusion bonding, hot isostatic pressing, ceramic-ceramic composites. These reports were presented at a workshop held March 27 to 29, 1985 in Santa Barbara, California. GRA

N87-20960# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Net Shape Technology in Aerospace Structures.
NET SHAPE TECHNOLOGY IN AEROSPACE STRUCTURES. VOLUME 4. APPENDIX. FUTURE COMPOSITE MANUFACTURING TECHNOLOGY. PRESENTATIONS OF A WORKSHOP HELD ON SEPTEMBER 9-12, 1985 IN GAITHERSBURG, MARYLAND Final Report, 1984 - 1986
MORRIS A. STEINBERG Dec. 1986 689 p Workshop held in Gaithersburg, Md., 9-12 Sep. 1985
(Contract F49620-85-C-0107)
(AD-A176511) Avail: NTIS HC A99/MF A02 CSCL 13H

This report is in four volumes. Papers presented by invited speakers at the workshops appear in Volume 4 (composites). This document is an appendix to Net Shape Technology in Aerospace Structures, Vol. 1. It contains 46 reports by representatives of industry and the military on the use of composites in the design and manufacture of aircraft parts. These reports were presented at a workshop held September 9 to 12, 1985 at the National Bureau of Standards in Gaithersburg, Maryland. GRA

N87-20961# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Aircraft and Engine Development Testing.
AIRCRAFT AND ENGINE DEVELOPMENT TESTING Final Report, 1984 - 1985
Sep. 1986 81 p
(Contract F49620-85-C-0107)
(AD-A176711) Avail: NTIS HC A05/MF A01 CSCL 14B

This report is a study of the use, timing, and costs of development testing in the new aeronautical test facilities: the Aeropropulsion Systems Test Facility (ASTF), the National Transonic Facility (NTF), and the 80 ft x 120 ft low speed tunnel at NASA-Ames Research Center, California. GRA

N87-20962# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ACTIVITIES REPORT IN SYSTEMS Annual Report, 1985
Oct. 1986 24 p Original contains color illustrations
(ETN-87-99371) Avail: NTIS HC A02/MF A01

Numerical optimization of air combat maneuvers; icing of aircraft; integrated air data systems; flight tests of the Rustic ramrocket missile; additional propulsion force for projectiles; adaptive robust control of missiles; navigation aid by millimetric wave systems; optimization of geostationary satellite positioning with a low thrust motor; location of LEO satellites, a geostationary relay station; fine aiming system for intersatellite optical link; location of multiple paths of a VHF link; adaptive processing for thinned arrays; radar signature analysis; optimization of multilayer radar absorbent materials; sonar signature of complex objects; mechanical effects of high flux visible spectrum lasers on brittle materials, and optical degrading of infrared materials caused by exposure to rain are discussed. ESA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A87-31624
EXPERIENCES WITH THE NUMERICAL SOLUTION OF THE 3-D LAMINAR BOUNDARY LAYER EQUATIONS IN STREAMLINE COORDINATES
W. SCHOENAUER and K. HAEFELE (Karlsruhe, Universitaet, West Germany) Computers and Fluids (ISSN 0045-7930), vol. 15, no. 1, 1987, p. 93-118. Research supported by the Stiftung Volkswagenwerk. refs

Problems which arise in the context of the numerical solution of the three-dimensional laminar boundary layer equations in streamline-potentialline coordinates are discussed. General (nonsymmetric) three-dimensional configurations can be treated by a selfadaptive variable step size/variable order method which tries to balance all relevant numerical errors to a prescribed relative tolerance. The existence of 'dividing streamlines' for general configurations causes serious difficulties. The method is applied to a general fuselage-like and an airfoil-like ellipsoid with yaw. An interesting comparison between the computational results and the measurements is made for a 6:1 prolate spheroid. Author

A87-31713
HYPERSONIC NONUNIFORM FLOW OF A VISCOUS GAS PAST A BLUNT BODY [GIPERZVUKOVOE OBTEKANIE ZATUPLENNOGO TELA NERAVNOMERNYM POTOKOM VIAZKOGO GAZA]
N. N. PILIUGIN and R. F. TALIPOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1986, p. 120-125. In Russian. refs

A self-similar solution to equations of the viscous boundary layer near the critical point is obtained for the case of supersonic flow past an axisymmetric blunt body located behind another body. The results are then used to develop a criterion for nonseparated flow. The effect of flow nonuniformity and Reynolds number on shock detachment, convective thermal flow, and the friction resistance of the blunt body is examined. V.L.

A87-31717
NONSTATIONARY AND NONEQUILIBRIUM AIR FLOW IN THE VICINITY OF THE CRITICAL FLOW LINE [NESTATSIONARNOE I NERAVNOVESNOE TECHENIE VOZDUKHA V OKRESTNOSTI KRITICHESKOI LINII TOKA]
M. B. ZHELEZNIAK, A. KH. MNATSAKANIAN, and S. V. PERVUKHIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1986, p. 170-172. In Russian. refs

The problem of gas flow ahead of the frontal point of a blunt body moving at a supersonic velocity in air with variable parameters is investigated with allowance for the processes of chemical relaxation behind the front of the shock wave. Numerical calculations are carried out using the method of characteristics, with the isolation of the bow shock. Determinations are made of the position of the shock wave front, which varies with time, and of the distributions of the composition and gasdynamic parameters in the shock layer. V.L.

A87-31729

CONSTRUCTION OF A GENERATING SOLUTION AND A GENERATING SYSTEM OF EQUATIONS IN A STUDY OF SELF-OSCILLATORY PARACHUTE MOTION [O POSTROENII POROZHDAIUSHCHEGO RESHENIIA I POROZHDAIUSHCHEI SISTEMY URAVNENII PRI IZUCHENII DVIZHENIIA PARASHIUTA V REZHIME AVTOKOLEBANII]

V. V. PUSTOVALOV and M. V. SOROKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 47-51. In Russian. refs

A generating solution and a generating system of equations are constructed in the problem of self-oscillatory parachute motion, these expressions being required for stability analysis in terms of the small parameter. In addition to the fundamental harmonics, the generating solution allows for the double-frequency harmonics. The corresponding generating system of equations is constructed in such a way that all the independent solutions of the system are nonincreasing. V.L.

A87-32069

PROPFAN INSTALLATION AERODYNAMICS STUDIED

Aerospace Engineering (ISSN 0736-2536), vol. 7, Feb. 1987, p. 18-22.

NASA-Ames studies of installation approaches for single-rotation propfan propulsion systems (SRPs) are described. A wing-mounted SRP in a tractor configuration and techniques for measuring thrust and drag were examined. The testbed was a wing-body-nacelle model with the SRP either under (UTW) or contoured over a wing mounted on a floor balance in a wind tunnel. Thrust was monitored in the exhaust nozzle and oil streak photography revealed the pressure contours. Sample results, such as drag variations and causes, flowfield separation, chord extension to recover swirl energy, and the addition of strakes to lower nacelle drag, are discussed. The tests confirmed SRP installation requires extensive tailoring of the wing and nacelle, especially with regard to controlling slipstream effects. M.S.K.

A87-32105#

CALCULATION OF TRANSONIC POTENTIAL FLOW THROUGH A TWO-DIMENSIONAL CASCADE USING AF1 SCHEME

KENJI INOUE (National Aerospace Laboratory, Tokyo, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 29, Nov. 1986, p. 171-183. refs

A method is presented for calculating the flow field about a cascade of arbitrary two-dimensional blades. A conformal transformation is used to generate a finite-difference grid. An implicit approximate factorization (AF) scheme is used for the solution of matrix equations resulting from a finite-difference approximation to the full potential equation in conservation form. For transonic flows, an artificial viscosity, required to maintain stability in supersonic regions, is introduced by an upwind bias of the density. This allows the simple matrix form of the scheme to be retained over the entire flow field. Supercritical test cases are considered. Blade Mach number or pressure distributions have been computed and found to be in good agreement with independent results. Author

A87-32115

SUPERSONIC INVISCID-FLOW - A THREE-DIMENSIONAL CHARACTERISTICS APPROACH

JEFFERSON FONG (Florida State University, Tallahassee) and LAWRENCE SIROVICH (Brown University, Providence, RI) Journal of Computational Physics (ISSN 0021-9991), vol. 68, Feb. 1987, p. 378-392. USAF-supported research. refs
(Contract NSF CHE-83-04021; DE-FC05-85ER-25000)

A method of near characteristics is used to model supersonic flow past nonaxisymmetric bodies. The computations are carried out in cylindrical coordinates, with the flow divided into a set of azimuthal planes and the method of characteristics applied to each plane. The forcing terms of the equations are supplied by the 'crosstalk', i.e., the azimuthal derivatives and velocities, between the planes. The method is shown to yield rigorous satisfaction of the Courant-Friedrichs-Lewy condition. Sample results are provided for supersonic flows past bodies with elliptical cross sections and azimuthal parabolic profiles. M.S.K.

A87-32160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DIRECT SIMULATION OF HYPERSONIC FLOWS OVER BLUNT WEDGES

JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) and VINCENT CUDA, JR. Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 1, April 1987, p. 97-104. Previously cited in issue 18, p. 2608, Accession no. A86-39944. refs

A87-32353

EXPERIMENTAL INVESTIGATIONS OF SEPARATED FLOW AROUND HIGH-ANGLE-OF-ATTACK SLENDER BODIES

HIROTOSHI KUBOTA, MASAYOSHI MATSUZAKA, TADAHARU WATANUKI (Tokyo, University, Japan), and KOJIRO SUZUKI IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 593-598. refs

Wind tunnel investigations on the aerodynamic characteristics of high-angle-of-attack slender bodies are performed with the use of force measurements and flow visualization. Effects of body shape, angle of attack, Reynolds number, and Mach number are examined. The detailed flow visualization reveals that asymmetric flow separation causes the singularities of the aerodynamic characteristics. Author

A87-32585

FLOW PATTERNS OF A PIVOTED RECTANGULAR WING AIRCRAFT

YUTAKA YAMAGUCHI and IWAO SHISHIKURA (National Defense Academy, Yokosuka, Japan) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p. refs
(SAE PAPER 861645)

Most of the researches on the pivoted wing concept were performed with elliptic wings of relatively high aspect ratio at zero oblique angle. But, from the practical point of view, it may be important to evaluate the aerodynamic characteristics of non-elliptic wings, such as the rectangular or the tapered wings. The authors selected a rectangular wing and obtained the preliminary experimental results on the flow patterns and aerodynamic characteristics of a pivoted wing aircraft with a rectangular wing in low to high subsonic flows in order to evaluate the applicability of this configuration to a cruising vehicle. The aerodynamic characteristics of the rectangular pivoted wing aircraft showed a fair agreement with the experimental results of NASA which used the elliptic wing, but the flow patterns on the wing surface at relatively high angle of attack were quite different from the expectation. Author

A87-32609

FLOW SIMULATIONS FOR AN AFT-MOUNTED PROPFAN USING EULER EQUATIONS

N. J. YU, K. KUSUNOSE, H. C. CHEN (Boeing Co., Seattle, WA), and D. M. SOMMERFIELD SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p. Research supported by the Boeing Independent Research and Development Program. refs
(SAE PAPER 861718)

A new transonic flow analysis program based on the solution of Euler equations has been developed. The program is capable of analyzing the flow over a complete wing/body/tail/aft-mounted propfan configuration at arbitrary freestream conditions. Computed results for an advanced aft-mounted propfan configuration with and without propeller are reported in this paper. Author

A87-32610*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INSTALLATION AERODYNAMICS OF WING-MOUNTED, SINGLE-ROTATION PROPFANS
DANIEL P. BENCZE, RONALD C. SMITH, and ALAN D. LEVIN (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p. refs
(SAE PAPER 861719)

The installation of advanced (M = 0.8) turboprop propulsion systems on transport aircraft represents a challenging task to design engineers. The installation aerodynamics of wing-mounted, single-rotation, tractor turboprop systems have been extensively investigated by NASA Ames using a large powered semispan wind tunnel model. Two configurations have been studied: a straight under-the-wing (UTW) nacelle and a contoured over-the-wing (OTW) configuration. The installation characteristics of these two configurations are presented in terms of installed drag, wing pressure distributions, and surface oil flows. Through the use of wing leading-edge modifications, the installed drag of the UTW nacelle was reduced to less than isolated nacelle drag at the cruise condition of M = 0.8 with a wing C(L) of 0.5. At this condition, the favorable interference is attributed to the recovery of a portion of the swirl in the slipstream generated by the single rotation propeller. The OTW installation represented a much more difficult task. For the configuration tested, the installed drag was unacceptably high and demonstrated the sensitive nature of installing a nacelle/slipstream combination in the transonic flow regime. Author

A87-32619* Lockheed-Georgia Co., Marietta.
HIGH SPEED WIND TUNNEL TESTS OF THE PTA AIRCRAFT
A. S. ALJABRI and B. H. LITTLE, JR. (Lockheed-Georgia Co., Marietta) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p. refs
(Contract NAS3-24339)
(SAE PAPER 861744)

Propfans, advanced highly-loaded propellers, are proposed to power transport aircraft that cruise at high subsonic speeds, giving significant fuel savings over the equivalent turbofan-powered aircraft. NASA is currently sponsoring the Propfan Test Assessment Program (PTA) to provide basic data on the structural integrity and acoustic performance of the propfan. The program involves installation design, wind-tunnel tests, and flight tests of the Hamilton Standard SR-7 propfan in a wing-mount tractor installation on the Gulfstream II aircraft. This paper reports on the high-speed wind-tunnel tests and presents the computational aerodynamic methods that were employed in the analyses, design, and evaluation of the configuration. In spite of the complexity of the configuration, these methods provide aerodynamic predictions which are in excellent agreement with wind-tunnel data. Author

A87-32626* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SUMMARY OF REYNOLDS NUMBER EFFECTS ON SOME RECENT TESTS IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
C. B. JOHNSON, W. G. JOHNSON, JR., and P.G. STAINBACK (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p. refs
(SAE PAPER 861765)

Reynolds number effects noted from selected test programs conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT) are discussed. The tests, which cover a unit Reynolds number range from about 2.0 to 80.0 million per foot, summarize effects of Reynolds number on: (1) aerodynamic data from a supercritical airfoil, (2) results from several wall interference correction techniques, and (3) results obtained from advanced, cryogenic tests techniques. The test techniques include: (1) use of a cryogenic sidewall boundary layer removal system, (2) detailed pressure and hot wire measurements to determine test section flow quality, and (3) use of a new hot film system suitable for transition detection in a cryogenic wind tunnel. The results indicate that Reynolds number effects appear most significant when boundary layer transition effects are present and at high lift conditions when boundary layer separation exists on both the model and the tunnel sidewall. Author

A87-32627* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SUMMARY OF THE EFFECTS OF REYNOLDS NUMBER ON DRAG DIVERGENCE FOR AIRFOILS TESTED IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
RENALDO V. JENKINS (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p. refs
(SAE PAPER 861767)

The direct first order effect of Reynolds number on the determination of drag-divergence conditions is summarized for six airfoils which were tested in the Langley 0.3-Meter Transonic Cryogenic Tunnel. A second order effect, derived through the effect of Reynolds number on the sidewall boundary layer, is included. In addition, a comparison of how the drag divergence condition is affected on going from one class of airfoil to another is presented. The drag-divergence condition is affected first order by Reynolds number for each of the six airfoils and of course all data are affected second order, since the presence of the boundary layer necessitates a sidewall correction. Author

A87-32629* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE EDDY BREAKUP DEVICES AS LOW REYNOLDS NUMBER AIRFOILS
JOHN B. ANDERS (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 12 p. refs
(SAE PAPER 861769)

Turbulent drag reduction downstream of large-eddy breakup (LEBU) devices is analyzed from the viewpoint of low-Reynolds number airfoil aerodynamics. It is argued that the variability of results between different research labs is primarily due to low Reynolds number 'phenomena' associated with unsteady separation/transition of the LEBU device boundary layer. LEBU drag reduction is shown to be an extremely sensitive function of device microgeometry at the low Reynolds numbers of all current investigations, and by analogy with conventional low-Reynolds number airfoil testing, the conclusion is drawn that the full potential for LEBU drag reduction must be explored at chord Reynolds numbers of 300,000 and above. Author

A87-32723
A THIN WING IN COMPRESSIBLE FLOW (2ND REVISED AND ENLARGED EDITION) [TONKOE KRYLO V SZHIMAEMOM POTOKE /2ND REVISED AND ENLARGED EDITION/]
ELENA ALEKSANDROVNA KRASILSHCHIKOVA Moscow, Izdatel'stvo Nauka, 1986, 288 p. In Russian. refs

A mathematical theory is presented for small perturbations of a gas due to the motion of a thin wing and acoustic waves interacting with the wing. An efficient method based on the use of integral equations in characteristic coordinates is proposed and applied to the aerodynamic problem of supersonic flow of a gas past a finite wing of arbitrary planform; both the case of stationary flow and the case of steady-state harmonic vibration of a wing are considered. A method is also presented for solving three-dimensional nonstationary problems in gas dynamics by representing the velocity potential in the form of a surface integral in space-time variables. Solutions in quadratures are presented for a series of aerodynamic problems. V.L.

A87-33164

POROUS AEROFOIL ANALYSIS USING VISCOUS-INVISCID COUPLING AT TRANSONIC SPEEDS

CHARLES R. OLLING (Lockheed-California Co., Burbank) and GEORGE S. DULIKRAVICH (Pennsylvania State University, State College) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Feb. 1987, p. 103-129. refs

Viscous-inviscid interaction is used to compute steady two-dimensional, transonic flows for solid and porous aerofoils. A full-potential code was coupled with both a laminar/transition/turbulent integral boundary-layer/turbulent wake code and the finite-difference boundary-layer code using the semi-inverse methods of Carter and Wigton. The coupling was performed using the transpiration coupling concept, thus allowing for analysis of porous aerofoils with passive physical transpiration. The computations confirm experimental findings that passive physical transpiration can lead to a lower drag coefficient and a higher lift coefficient, a weaker shock and elimination of shock-induced separation. Nevertheless, it is very important that the extent of the porous region and permeability factor distribution of the porous region are chosen carefully if these improvements are to be achieved. Author

A87-33168

AERODYNAMICS OF A DOUBLE MEMBRANE AIRFOIL

GUIDO DE MATTEIS (Roma I, Universita, Rome, Italy) Meccanica (ISSN 0025-6455), vol. 21, Dec. 1986, p. 205-209. Research supported by the Ministero della Pubblica Istruzione. refs

Steady potential flow around an inflated two-dimensional lenticular airfoil is considered. The flow and the shape of the airfoil are determined by simulating the flexible surfaces by means of a chain of rectilinear tracts. Numerical results extend the already known data of the linearized theory for nonlifting symmetric configurations. In the lifting case, the effects of angle of attack, slack, and internal pressure on the aerodynamic characteristics are analyzed. Author

A87-33239#

MEASURED AND CALCULATED STRESS IN A RIBBON PARACHUTE CANOPY

WILLIAM L. GARRARD, MICHAEL L. KONICKE, K. S. WU, and K. K. MURAMOTO (Minnesota, University, Minneapolis) Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 65-72. Research supported by Sandia National Laboratories. Previously cited in issue 11, p. 1498, Accession no. A84-26580. refs

A87-33241#

EFFECT OF STRAKES ON THE AUTOROTATIONAL CHARACTERISTICS OF NONCIRCULAR CYLINDERS

B. N. PAMADI (Indian Institute of Technology, Bombay, India) and H. S. PORDAL Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 84-97. refs

An experimental investigation is conducted to evaluate the effects of windward strakes on the autorotational characteristics of a typical noncircular cylinder. The results indicate that autorotational speeds are very sensitive to strake height and, more particularly, to their location. Reductions in autorotational speeds by as much as 75 percent were obtained for a strake height of 0.3 located at a cylinder width position of 0.2. Exploratory two-dimensional pressure measurements indicated that the strakes themselves develop significant, pro- or antiautorotational side forces depending on their location. A strip theory analysis showed that a reduction in cross-flow angle is mainly responsible for this phenomenon. Author

A87-33242*# Texas A&M Univ., College Station.

DIRECT-INVERSE METHOD FOR AIRFOILS AT HIGH ANGLES OF ATTACK

LELAND A. CARLSON (Texas A & M University, College Station) Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 98-106. Previously cited in issue 07, p. 831, Accession no. A86-19766. refs

(Contract NSG-1174)

A87-33244*# California Univ., Davis.

INDUCED-DRAG CHARACTERISTICS OF CRESCENT-MOON-SHAPED WINGS

C. P. VAN DAM (California, University, Davis) Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 115-119. NASA-supported research. Previously cited in issue 17, p. 2463, Accession no. A86-37840. refs

A87-33246#

ADVANCED METHOD FOR COMPUTING FLOW AROUND WINGS WITH REAR SEPARATION AND GROUND EFFECT

KLAUS JACOB (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 126-128.

The present method for the determination of wing flow pressure distributions, total lift, drag, and pitching moment, in conditions of rear separation and ground effect, satisfies the kinematic flow condition at the ground by applying the well known reflected image concept to both the lifting surface theory and the two-dimensional airflow method. The pronounced effects of the finite span and of the ground are well predicted, even for rather high angles of attack. O.C.

A87-33327

STUDIES OF THE FLOW FIELD NEAR A NACA 4412 AEROFOIL AT NEARLY MAXIMUM LIFT

R. C. HASTINGS and B. R. WILLIAMS (Royal Aircraft Establishment, Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Jan. 1987, p. 29-44. refs

Wing surface and wing midspan-proximate wind tunnel wall static pressure distribution measurements are conducted at Mach 0.18 and a chord-based Reynolds number of 4.2 million on a constant-chord NACA 4412 airfoil section model; results are compared with those of flow field calculations. Attention is given to the development of the upper surface boundary layer through separation and into the wake, using laser anemometry to to measure mean velocities. The flow field calculations used are of the semiinverse kind, in which an inverse momentum-integral treatment of the shear flow is coupled to a direct solution of the inviscid flow problem. O.C.

A87-33453

CURVATURE AND PRESSURE-GRADIENT EFFECTS ON A SMALL-DEFECT WAKE

A. NAKAYAMA (Douglas Aircraft Co., Aerodynamics Research and Technology Dept., Long Beach, CA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 175, Feb. 1987, p. 215-246. refs

(Contract NSF MEA-80-18565)

A fully developed two-dimensional turbulent wake was deflected by an airfoil-like thin plate placed at small angles in the external flow. The response of the mean-flow and turbulence properties of the wake to the 'mild' pressure gradient and the 'mild' streamline curvature caused by the deflection is studied. Owing to the small defect velocity, the extra strain rates are large compared with the main shear strain and the Reynolds stresses are strongly influenced by both the pressure gradient and the streamline curvature. The defect velocity relative to an appropriately chosen 'potential-flow velocity', and the mean vorticity, however, are not as strongly influenced by the curvature. Changes in the magnitudes of the Reynolds-stress components are much larger than would be caused by the simple rotation of coordinates aligned with the wake path. Most turbulence-model parameters are influenced significantly, while some pure turbulence parameters, such as the Taylor microscale, are relatively uninfluenced. The rapid and lagged responses are apparent and the terms in the transport equation for turbulent kinetic energy indicate that the response of the production terms is almost instantaneous, while the diffusion and dissipation terms are delayed. Author

A87-33655#
APPLICATIONS OF A FAST, TIME ACCURATE FULL POTENTIAL SCHEME TO A STATICALLY FLEXIBLE WING IN THE TRANSONIC REGIME
H. IDE (Rockwell International Corp., Los Angeles, CA) and V. J. SHANKAR (Rockwell International Science Center, Thousand Oaks, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-6. refs
(AIAA PAPER 87-0707)

A new CFD/aeroelastic method has been developed. This method is based on a robust unsteady full potential code to calculate aerodynamic forces of flexible wings in the transonic flight regime. The procedure to incorporate aeroelastic structural deflections into the geometry definition and the subsequent grid generation phase for aerodynamic analysis has done through boundary condition treatment at the instantaneous surface location. Author

A87-33657*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC AEROELASTICITY OF WINGS WITH ACTIVE CONTROL SURFACES
GURU P. GURUSWAMY (Sterling Federal Systems, Palo Alto, CA), PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), and EUGENE L. TU IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 16-30. refs
(AIAA PAPER 87-0709)

Transonic aeroelasticity of wings with active control surfaces is studied by using the unsteady-small disturbance transonic aerodynamic equations coupled with modal structural equations of motion. The aerodynamic and structural equations of motion are simultaneously integrated by a time-accurate numerical scheme. A procedure of synthesizing active controls with unsteady transonics is presented. Flutter suppression in the transonic regime using active controls is demonstrated for a rectangular wing. Characteristics of a selected control law in the transonic regime are studied. The results from this study are useful in the design of active control systems in the transonic regime. Author

A87-33662*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INVESTIGATION OF TRANSONIC REGION OF HIGH DYNAMIC RESPONSE ENCOUNTERED ON AN ELASTIC SUPERCRITICAL WING
DAVID A. SEIDEL, CLINTON V. ECKSTROM, and MAYNARD C. SANDFORD (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 66-75.
(AIAA PAPER 87-0735)

Unsteady aerodynamic data were measured on an aspect ratio 10.3 elastic supercritical wing while undergoing high dynamic response above Mach number of 0.90. These tests were conducted in the NASA Langley Transonic Dynamics Tunnel. A previous test of this wing predicted an unusual instability boundary based upon subcritical response data. During the present test no instability was found, but an angle of attack dependent narrow Mach number region of high dynamic wing response was observed over a wide range of dynamic pressures. The effect on dynamic wing response of wing angle of attack, static outboard control surface deflection and a lower surface spanwise fence located near the 60 percent local chordline was investigated. The driving mechanism of the dynamic wing response appears to be related to chordwise shock movement in conjunction with flow separation and reattachment on both the upper and lower surfaces. Author

A87-33690*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR REALISTIC AIRCRAFT CONFIGURATIONS
JOHN T. BATINA, DAVID A. SEIDEL, SAMUEL R. BLAND, and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 344-362. refs
(AIAA PAPER 87-0850)

A transonic unsteady aerodynamic and aeroelasticity code has been developed for application to realistic aircraft configurations. The new code is called CAP-TSD which is an acronym for Computational Aeroelasticity Program - Transonic Small Disturbance. The CAP-TSD code uses a time-accurate approximate factorization (AF) algorithm for solution of the unsteady transonic small-disturbance equation. The AF algorithm is very efficient for solution of steady and unsteady transonic flow problems. It can provide accurate solutions in only several hundred time steps yielding a significant computational cost savings when compared to alternative methods. The new code can treat complete aircraft geometries with multiple lifting surfaces and bodies including canard, wing, tail, control surfaces, launchers, pylons, fuselage, stores, and nacelles. Applications are presented for a series of five configurations of increasing complexity to demonstrate the wide range of geometrical applicability of CAP-TSD. These results are in good agreement with available experimental steady and unsteady pressure data. Calculations for the General Dynamics one-ninth scale F-16C aircraft model are presented to demonstrate application to a realistic configuration. Unsteady results for the entire F-16C aircraft undergoing a rigid pitching motion illustrated the capability required to perform transonic unsteady aerodynamic and aeroelastic analyses for such configurations. Author

A87-33691*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CALCULATION OF STEADY AND UNSTEADY PRESSURES ON WINGS AT SUPERSONIC SPEEDS WITH A TRANSONIC SMALL DISTURBANCE CODE
ROBERT M. BENNETT, SAMUEL R. BLAND, JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA), MICHAEL D. GIBBONS (PRC Kentron International, Hampton, VA), and DENNIS G. MABEY (Royal Aircraft Establishment, Dynamics Laboratory, Bedford, England) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 363-377. refs
(AIAA PAPER 87-0851)

A transonic unsteady aerodynamic and aeroelasticity code has been developed for application to realistic aircraft configurations. The new code is called CAP-TSD which is an acronym for Computational Aeroelasticity Program - Transonic Small Disturbance. The CAP-TSD code uses a time-accurate approximate factorization algorithm for solution of the unsteady transonic small-disturbance equation that is efficient for solution of steady and unsteady transonic flow problems including supersonic freestream flows. The new code can treat complete aircraft geometries with multiple lifting surfaces and bodies. Applications to wings in supersonic freestream flow are presented. Comparisons with selected exact solutions from linear theory are presented showing generally favorable results. Calculations for both steady and oscillatory cases for the F-5 and RAE tailplane models are compared with experimental data and also show good overall agreement. Selected steady calculations are further compared with a steady flow Euler code. Author

A87-33692#
UNSTEADY TRANSONIC AERODYNAMICS OF OSCILLATING AIRFOILS IN SUPERSONIC FREESTREAM
D. D. LIU (Arizona State University, Tempe), K. Y. FUNG (Arizona, University, Tucson), C. H. WANG, and D. K. JAMES IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 378-397. Navy-supported research. refs
(AIAA PAPER 87-0852)

Nonlinear unsteady transonic/supersonic flows over airfoils are studied comparatively by two computational codes based on the small disturbance theory. While the AZTRAN code is unified for all transonic Mach-number ranges, TMOC code is restricted to the shock-attachment cases. The computed results are verified with each other and with those of the ATRAN2 code, the linear theory, and other data whenever appropriate. Cases of study include inverse airfoil design, sonic point investigations, computations of pressures for airfoil in pitching, plunging and flap oscillations, and calculations of stiffness and damping moments. Finally, calculations of bending-torsion flutters according to linear and nonlinear theories are presented for a sharp and two blunt-leading-edge airfoils. The findings indicate that the transonic nonlinearity plays an essential role in this Mach number range. Author

A87-33694*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR PROGRAMMING EXTENSIONS TO RATIONAL FUNCTION APPROXIMATIONS OF UNSTEADY AERODYNAMICS
SHERWOOD H. TIFFANY and WILLIAM M. ADAMS, JR. (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 406-420. refs
(AIAA PAPER 87-0854)

This paper deals with approximating unsteady generalized aerodynamic forces in the equations of motion of a flexible aircraft. Two methods of formulating these approximations are extended to include both the same flexibility in constraining them and the same methodology in optimizing nonlinear parameters as another currently used 'extended least-squares' method. Optimal selection of 'nonlinear' parameters is made in each of the three methods by use of the same nonlinear (nongradient) optimizer. The objective of the nonlinear optimization is to obtain rational approximations to the unsteady aerodynamics whose state-space realization is of lower order than that required when no optimization of the nonlinear terms is performed. The free 'linear' parameters are determined using least-squares matrix techniques on a Lagrange multiplier formulation of an objective function which incorporates selected linear equality constraints. State-space mathematical models resulting from the different approaches are described, and results are presented which show comparative evaluations from application of each of the extended methods to a numerical example. The results obtained for the example problem show a significant (up to 63 percent) reduction in the number of differential equations used to represent the unsteady aerodynamic forces in linear time-invariant equations of motion as compared to a conventional method in which nonlinear terms are not optimized. Author

A87-33703#
FLUTTER CALCULATIONS USING DOUBLET LATTICE AERODYNAMICS MODIFIED BY THE FULL POTENTIAL EQUATIONS
DALE M. PITT and CHARLES E. GOODMAN (McDonnell Douglas Corp., Saint Louis, MO) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 506-512. refs
(AIAA PAPER 87-0882)

A technique is described for modifying unsteady Doublet Lattice aerodynamics using correction factors based on a steady state Computational Fluid Dynamic (CFD) program. The steady transonic aerodynamic program FL028, which solves the steady full potential equation for a swept wing, is used in calculating the correction factors. This CFD correction factor technique allows the Doublet Lattice aerodynamics to be modified to account for transonic shock effects, wing thickness, wing twist, angle-of-attack, camber, and airfoil shape. The modified Doublet Lattice aerodynamics are used to calculate flutter results for two fighter aircraft, the AV-8B and F/A-18. The calculated flutter results show both transonic shock and angle-of-attack effects. Author

A87-34042
FAST TIME MARCHING APPROACH TO CASCADE TRANSONIC FLOW
FRANCESCO MARTELLI and LUCA MARCHI (Firenze, Universita, Florence, Italy) IN: International Conference on Nonlinear Mechanics, Shanghai, People's Republic of China, Oct. 28-31, 1985, Proceedings . Beijing, Science Press, 1985, p. 773-780. refs

Time marching solutions of the transonic flow are widely used for the analysis of turbomachinery cascades. The transonic flow calculation is a typical problem where nonlinear effects have a big influence. Any attempt to increase the efficiency, and the computational speed, which are, at the present, the main goals of the research in that field, has to be faced with the nonlinearities of the mathematical model. The aim of the paper is the presentation of a new pseudo-time dependent method to try to achieve those goals through a correct management of the nonlinear aspects of the problem. The method, the basic idea and the procedure used to develop the new formulation are briefly described and discussed. Some applications of the method to transonic turbine cascades are presented against experimental results, and the accuracy and speedness of the method is discussed. Author

A87-34048
THE SOLUTION OF UNSTATIONARY VISCOUS FLOW IN TURBOMACHINE BY ORTHOGONAL FINITE ELEMENT METHODS
AIXIANG HUANG and BIJIAN FAN (Xian Jiaotong University, People's Republic of China) IN: International Conference on Nonlinear Mechanics, Shanghai, People's Republic of China, Oct. 28-31, 1985, Proceedings . Beijing, Science Press, 1985, p. 1218-1226. Research supported by the Chinese Academy of Sciences.

A87-34505*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASURED UNSTEADY TRANSONIC AERODYNAMIC CHARACTERISTICS OF AN ELASTIC SUPERCRITICAL WING
DAVID A. SEIDEL, MAYNARD C. SANDFORD, and CLINTON V. ECKSTROM (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 64-71) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 225-230. Previously cited in issue 13, p. 1845, Accession no. A85-30327. refs

A87-34507#
WING AND CONICAL BODY OF ARBITRARY CROSS SECTION IN SUPERSONIC FLOW
DAN MATEESCU (McGill University, Montreal, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 239-247. Previously cited in issue 17, p. 2463, Accession no. A86-37841. refs

A87-34513#
COMPUTATIONAL METHOD FOR SCREENED TWO-DIMENSIONAL WIND TUNNEL INLETS
W. J. COIRIER and M. B. BRAGG (Ohio State University, Columbus) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 281-283.

Attention is given to an elliptic grid generation method that applies the property of total constant head levels to the streamlines of an incompressible inviscid flow, in order to predict the two-dimensional flowfields of screened subsonic wind tunnel inlet flowfields. Existing elliptic grid generation codes could be readily modified to attain this capacity by evaluating the source term in such a way as to model the effect of the turbulence screens on the total head distribution. O.C.

A87-34723*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF VISCOUS TRANSONIC FLOW OVER AIRFOIL SECTIONS
DENNIS L. HUFF (NASA, Lewis Research Center, Cleveland, OH), JIUNN-CHI WU, and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 32 p. Previously announced in STAR as N87-17001. refs
(AIAA PAPER 87-0420)

A full Navier-Stokes solver has been used to model transonic flow over three airfoil sections. The method uses a two-dimensional, implicit, conservative finite difference scheme for solving the compressible Navier-Stokes equations. Results are presented as prescribed for the Viscous Transonic Airfoil Workshop to be held at the AIAA 25th Aerospace Sciences Meeting. The NACA 0012, RAE 2822 and Jones airfoils have been investigated for both attached and separated transonic flows. Predictions for pressure distributions, loads, skin friction coefficients, boundary layer displacement thickness and velocity profiles are included and compared with experimental data when possible. Overall, the results are in good agreement with experimental data. Author

A87-34851* JAI Associates, Mountain View, Calif.
NUMERICAL SIMULATIONS OF UNSTEADY AIRFOIL-VORTEX INTERACTIONS
G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA) and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 3-23, 25-28. Army-supported research. refs
(Contract NAS2-11331)

Numerical methods based on the thin layer Navier-Stokes, Euler and transonic small disturbance equations, all three of which use the perturbation form of an implicit numerical algorithm, are used to formulate the unsteady interactions of a moving vortex with a stationary airfoil. Results are presented for both transonic and subsonic flows, as well as for weak and strong interactions. In general, the results exhibit an overwhelming influence of the vortex on the flow field around the airfoil, especially when the convecting vortex is within one chord of the airfoil. It is noted that even the ostensibly weak interactions produced vortex/shock-induced boundary layer separation. O.C.

A87-35008#
VISUALIZATION OF SEPARATED VORTICES USING LASER INDUCED FLUORESCENCE
M. ZIMMERMANN and R. B. MILES (Princeton University, NJ) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 49-53. Research supported by the Boeing Commercial Aircraft Co. and USAF. refs

The use of laser-induced fluorescence (LIF) for visualization of three-dimensional compressible turbulent flow is examined. The experimental facility and procedures employed for the visualization of separating vortices are described. The two counter rotating vortices detected are analyzed. The advantages of applying LIF to flow visualization are discussed. It is noted that the technique is also useful for providing data on the velocity, pressure, and temperature of a flow. I.F.

A87-35013#
FULL POTENTIAL TRANSONIC MULTIGRID CODE FOR ARBITRARY CONFIGURATIONS
A. L. LUNTZ and B. EPSTEIN (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 87-92. refs

The multigrid full potential code for arbitrary configurations is described. The code uses three-dimensional Cartesian equally meshed computational grids and is composed of a PREPRO and a MULTIG code; the functions of these codes are discussed. The equation and numerical discretization scheme and surface boundary condition are examined. Consideration is given to multigrid level interaction and local refinement, overlapping, and multigrid treatment of potential wake jump. Examples illustrating the applicability of the code are provided. I.F.

A87-35016#
AERODYNAMIC COEFFICIENTS OF A THIN WING WITH ELLIPTIC PLANFORM IN UNSTEADY MOTION
A. HAUPTMAN and T. MILOH (Tel Aviv University, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 142-147. refs

An analytic solution is presented for the linearized lifting-surface problem of a thin wing with elliptic planform in unsteady incompressible flow. The analysis is based on expansion of the acceleration potential in infinite series of ellipsoidal harmonics, and extends the steady analysis recently developed by the authors, to the unsteady flow regime. Explicit expressions are obtained for both the starting lift in the case of impulsive acceleration and for the lift due to constant acceleration. The exact solution thus obtained is valid for the whole range of aspect ratios. The analytic result for the starting lift may be treated as new generalization of the classical Wagner's two-dimensional solution for planforms of finite aspect ratios. Author

N87-20193# Maryland Univ., College Park.
OPTIMIZATION OF HYPERSONIC WAVERIDERS DERIVED FROM CONE FLOWS INCLUDING VISCOUS EFFECTS Ph.D. Thesis
KEVIN GERALD BOWCUTT 1986 256 p
Avail: Univ. Microfilms Order No. DA8628966

Over the past two years, interest in all aspects of hypersonic flight has grown explosively, driven by new vehicle concepts such as the aerospace plane, aero-assisted orbital transfer vehicles, and hypersonic cruise vehicles, to name a few. High lift-to-drag ratio (L/D) is important for one reason or another to almost all of the hypersonic vehicle concepts currently under investigation, yet it is well known that high values of L/D are very difficult to obtain at hypersonic speeds, due to the presence of strong shock waves (hence high wave drag) and massive viscous effects. In fact, there is a general empirical correlation by Kuchemann based on actual

flight data for (L/D)max as a function of Mach number, given by (L/D)max = M sub infinity + 3 M sub infinity which represents a type of L/D barrier, which most real flight vehicles are unable to break. It is proposed to develop a new class of hypersonic vehicles which will overcome this L/D barrier. The vehicles are waveriders with windward surfaces derived from conical flows and optimized for maximum L/D. Included in the waverider analysis are upper surfaces derived from axisymmetric expansion flows, blunted leading edges to satisfy aerodynamic heating requirements, and most importantly, detailed viscous effects (including boundary layer transition). It is the inclusion of detailed viscous effects within the optimization process that makes the present work unique. Optimization is performed using a numerical non-linear minimization algorithm. Dissert. Abstr.

N87-20196 Stanford Univ., Calif.
A RATIONAL APPROACH TO LIFTING SURFACE THEORY WITH APPLICATION TO LARGE ANGLES OF ATTACK Ph. D. Thesis
BECKER VANNIEKERK 1986 165 p
Avail: Univ. Microfilms Order No. DA8700832

The acceleration potential formulation is advocated as an alternative to the velocity potential methods currently used to find the time accurate lift distributions on thin wings in unsteady subsonic flow. Advantages offered by the use of the acceleration potential are that compressibility can be accounted for and that no wake discretization is necessary. A classical variational statement is used to derive special properties of a weighted residual method. It is shown that some weighted integral of the sought solution can be obtained to second order accuracy in the solution to the original and adjoint problems. For aerodynamics, it is assumed that the reverse flow is adjoint to the original problem. In numerical solutions, the characteristic double pole singular integrals which arise in subsonic wing theory are integrated numerically with a new Gauss-type quadrature rule. This substantially simplifies the algebra involved in the use of kernel function methods. A detailed discussion of the possibility of using acceleration potential methods to do free wake analyses around slender wings is presented. Dissert. Abstr.

N87-20197 Georgia Inst. of Tech., Atlanta.
A NUMERICAL STUDY OF THE WEIS-FOGH MECHANISM Ph.D. Thesis
MYONGHAN SOHN 1986 190 p
Avail: Univ. Microfilms Order No. DA8628367

A numerical scheme is developed and utilized to study the time-dependent viscous flows about two-dimensional Weis-Fogh wings. The scheme uses the vorticity and the stream function as dependent variables. An integral representation is utilized to determine the surface vorticity and to calculate stream function values at the outer boundary of the computation field. Finite difference methods are used to solve the vorticity transport equation and the Poisson's equation for the stream function inside the computational domain. The present numerical scheme removes several restrictions encountered by previous investigators such as the inviscid flow assumption, flow Reynolds number limitation and the type of wing motion that may be treated. Two different types of wing motion, the fling and the fling followed by the moving apart of the wings, are treated for flow Reynolds numbers of 32 and 13000. The development of the flows around the wings are analyzed through the streamlines and equi-vorticity contours. Aerodynamic analyses are carried out through computed distributions of surface vorticity and surface pressure. The results confirm several experimental observations and successfully provide a physical interpretation of these observations. Several additional features of the aerodynamic load generation are revealed by the present study. The aerodynamic loads are found to be mainly a consequence of large suction pressure on the leeward surface caused by the strong separation vortex. The wings pump energy into the fluid at a high rate in the initial phase of fling. The Weis-Fogh wings obtain a significant gain in overall lift output through unsteady mechanisms. Dissert. Abstr.

N87-20199# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS IN AERONAUTICS
Loughton, England Nov. 1986 428 p In ENGLISH and FRENCH Symposium held in Aix-en-Provence, France, 7-10 Apr. 1986
(AGARD-CP-412; ISBN-92-835-0402-X) Avail: NTIS HC A19/MF A01

The goal of the symposium was to provide a balanced, if not exhaustive, assessment of the status of computational fluid dynamics in aerodynamic design and analysis, where CFD is making an increasingly major impact. The rapid progress in computer capability, the general availability of large scale computers and parallel achievements in numerical analysis, algorithm development and user experience were evidenced by the presentations. The sessions were divided into subject areas of: grid generation, inviscid flow, viscous-inviscid interactions, and Navier-Stokes solutions.

N87-20206*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE PREDICTION OF TRANSONIC LOADING ON ADVANCING HELICOPTER ROTORS
R. C. STRAWN and C. TUNG *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 14 p Nov. 1986
Avail: NTIS HC A19/MF A01

Two different schemes are presented for including the effect of rotor wakes on the finie-difference prediction of rotor loads. The first formulation includes wake effects by means of a blade-surface inflow specification. This approach is sufficiently simple to permit coupling of a full-potential finite-difference rotor code to a comprehensive integral model for the rotor wake and blade motion. The coupling involves a transfer of appropriate loads and inflow data between the two computer codes. Results are compared with experimental data for two advancing rotor cases. The second rotor-wake modeling scheme is a split potential formulation for computing unsteady blade-vortex interactions. Discrete vortex fields are introduced into a three-dimensional, conservative, full-potential rotor code. Computer predictions are compared with two experimental blade-vortex interaction cases. Author

N87-20207# Canadair Ltd., Montreal (Quebec).
PREDICTION OF WING-BODY-STORE AERODYNAMICS USING A SMALL PERTURBATION METHOD AND A GRID EMBEDDING TECHNIQUE
FASSI KAFYEKE *In* AGARD Applications of Computational Fluid Dynamics in AEronautics 13 p Nov. 1986 Sponsored by Department of National Defence of Canada
Avail: NTIS HC A19/MF A01

A computer program providing accurate and cost effective predictions of transonic flow fields about three dimensional configurations has been developed at Canadair. The computation scheme uses the Small Perturbation Equation and a grid embedding technique. The flow field is solved iteratively, using successive line overrelaxation. The comparisons between computed results and experiment for a wing-body and a generic wing-body-pylon-store configuration show that a good level of accuracy can be obtained with this approach. The program was written with the overall emphasis on lowering the computation time and is considered as a stepping stone towards a full aircraft-store aerodynamic simulation. The potential of the method for analyzing complex three dimensional configurations is discussed, showing that the code is a very practical tool for the design office, for parametric studies or as a lead program for more sophisticated investigations using Euler or Navier-Stokes solvers. Author

N87-20208# National Aerospace Lab., Amsterdam (Netherlands). Information Div.
MATRICS, TRANSONIC POTENTIAL FLOW CALCULATIONS ABOUT TRANSPORT AIRCRAFT
J. VANDERVOOREN, A. J. VANDERWEES, and J. H. MEELKER *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 14 p Nov. 1986 Sponsored in part by Netherlands Agency for Aerospace Programs (NIVR)
Avail: NTIS HC A19/MF A01

MATRICS is a system under development for the calculation of transonic (potential) flow about transport aircraft. The motivation for this development is discussed, as well as the basic concepts of the system. Details of the full potential flow solver, involving the newly developed Implicit Lower Upper decomposition/ Strongly Implicit Procedures (ILU/SIP) relaxation scheme, are given. A discussion on computer power required and some informatics aspects are also presented. Results of computations are presented and discussed. Author

N87-20209# British Aerospace Aircraft Group, Warton (England). Fluid Dynamics Section.
APPLICATIONS AND DEVELOPMENTS OF COMPUTATIONAL METHODS FOR THE AERODYNAMIC PROBLEMS OF COMPLEX CONFIGURATIONS
J. A. H. PETRIE and P. M. SINCLAIR *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 14 p Nov. 1986
Avail: NTIS HC A19/MF A01

Problems encountered by the Aerodynamicist at a military design site are characterised by complex geometry and complex flow conditions. Because of the limitations of current Computational Fluid Dynamics (CFD) technology, its use represents a compromise in one or both of these areas. The way in which sensible use of the current generation of CFD codes can generate useful aerodynamic design data is illustrated by three particular examples; wing design, installed store loading and the prediction of store release trajectories. Although these examples will show that data can be generated by such techniques, they are by no means ideal. As an alternative to the methods being widely developed which require a body fitted grid, BAe Brough is developing an integral method which uses a rectangular grid passing through the configuration surface(s). The theory behind this method will be presented together with some results which show the technique to have great promise. Author

N87-20214*# Massachusetts Inst. of Tech., Cambridge. CFD Lab.
APPLICATIONS OF EULER EQUATIONS TO SHARP EDGE DELTA WINGS WITH LEADING EDGE VORTICES
EARLL M. MURMAN and ARTHUR RIZZI (Aeronautical Research Inst. of Sweden, Bromma.) *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 13 p Nov. 1986 (Contract NAG1-358)
Avail: NTIS HC A19/MF A01

Studies on the solution of discrete Euler equations past swept delta wing configurations with sharp leding edges are presented. Freestream Mach numbers range from zero to supersonic, although the Mach number normal to the leading edge is subsonic for all cases discussed. A few examples are given to show the application of the numerical methods to representative problems. The major dicussion is directed at the application of Computational Fluid Dynamics to the understanding of the fundamental fluid mechanic mechanisms of this class of flows. Author

N87-20217# General Dynamics Corp., Fort Worth, Tex.
ANALYSIS OF THE F-16 FLOW FIELD BY A BLOCK GRID EULER APPROACH
STEVE L. KARMAN, JR., JOHN P. STEINBRENNER, and KEITH M. KISIELEWSKI *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 14 p Nov. 1986
Avail: NTIS HC A19/MF A01

A grid generation procedure was developed to create complex block grid systems, beginning with the generation of block surfaces, up to the generation of the full block volume grids. Parallel to this, a multiple block Euler equation solver was developed using a hybrid flux vector split and split MacCormack scheme, written to allow very general boundary conditions specification. The two codes are utilized herein to generate an inviscid analysis of an entire F-16 transonic flowfield. Preliminary results are presented and are seen to compare well with experimental data. Even better correlation with experimental data is expected once a fully converged solution is obtained. Author

N87-20218# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.
COMPARISON OF FINITE DIFFERENCE CALCULATIONS OF A LARGE REGION OF RECIRCULATING FLOW NEAR AN AIRFOIL TRAILING EDGE
L. REIS and B. E. THOMPSON (Waterloo Univ., Ontario.) *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 21 p Nov. 1986 Sponsored by British Ministry of Defense, Institute National de Investigacao Cientifica of Portugal and the National Science and Engineering Council of Canada
Avail: NTIS HC A19/MF A01

Calculations are presented for a turbulent boundary layer which separates upstream of a sharp trailing edge and results in a large region of recirculating flow and a curved downstream wake. The solutions obtained from two precedures that solve finite-difference equations formulated with hybrid combinations of upwind-central and bounded skew-upwind-central difference approximations for convective terms, are compared. Numerical error was smaller, and accordingly less false diffusion was apparent, in the bounded-skew calculations although there was no significant improvement in the agreement with experiment. Agreement between measured and calculated values of the lift coefficient was within 3% and required representation of momentum transport and pressure gradient normal to the surface, but the measured drag coefficient was less than 80% of that obtained in both calculations. Deficiencies are attributable, in part, to turbulence-model assumptions which do not represent the effects of stabilizing and destabilizing streamline curvature and the complex interaction of the backflow, pressure-side and curved suction-side boundary layers in the vicinity of the rear stagnation point downstream of the trailing edge. Author

N87-20221# Societe Nationale Industrielle Aerospatiale, Marignane (France). Div. Helicopteres.
THEORETICAL ANALYSIS OF FLOWS AROUND HELICOPTER FUSELAGES: APPLICATION TO DESIGN AND DEVELOPMENT
A. CLER *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 8 p Nov. 1986
Avail: NTIS HC A19/MF A01

Three dimensional aerodynamic calculations as applied to fuselage design are described. Three levels of complexity may be distinguished in the calculation programs: (1) a singularities method describing the potential flow around a fuselage, (2) an integral three dimensional boundary layer method for predicting three dimensional separations, and (3) a point vortex wake model. The first two methods are routinely used with very short response times, either on complete fuselages or for specific aircraft sections. Close agreement is obtained with the available experimental results. Various examples are given of applications to project or development work. Operational calculations cannot yet be performed with the wake model, as the method is still under development. In the current state of the art, aerodynamic calculations provide undeniable services but can by no means replace wind tunnel tests for determining complete aircraft drag. Author

N87-20224# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
APPLICATIONS OF RAE VISCOUS FLOW METHODS NEAR SEPARATION BOUNDARIES FOR THREE-DIMENSIONAL WINGS IN TRANSONIC FLOW
M. C. P. FIRMIN *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 14 p Nov. 1986
Avail: NTIS HC A19/MF A01

Three applications of computational fluid dynamics (CFD) at high subsonic speeds, with transonic flow, are presented. Two of these relate to the prediction of the pressure distribution over swept wings at conditions close to the separation boundary and one to the design of a swept wing for a wind-tunnel model. The methods involved are a potential flow treatment of the inviscid flow coupled with a three dimensional, integral treatment of the turbulent boundary layer. The coupling between the viscous and inviscid flow codes is direct, through a transpiration condition at the wing surface and on a surface downstream of the wing. Author

N87-20225# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
APPLICATION OF THE NAVIER-STOKES EQUATIONS TO SOLVE AERODYNAMIC PROBLEMS
J. S. SHANG and W. L. HANKEY (Wright State Univ., Dayton, Ohio.) *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986
Avail: NTIS HC A19/MF A01

An area presently evolving is Interdisciplinary Computational Fluid Dynamics (ICFD) in which the Navier-Stokes equations are coupled to another set of equations to solve interacting problems. The large computers approaching will permit elaborate solutions to these ICFD problems. Therefore, research on generic systems of equations by the CFD community is required to assist engineers to solve their coupled problems. Already some of the necessary research has been accomplished to solve ICFD problems. Advantage is taken of the present numerical algorithms and grid generation. The conservation form for the governing equations can be utilized and the field data to exploit vector processors can be arranged. However, new technology must be developed to model complex interface boundary conditions and to incorporate a variety of constitutive relationships for the state variables and transport processors. Also, it will become necessary to model many physical processes that are below subgrid scale. Examples of subgrid scale modeling phenomenon are turbulence, evaporation, atomization, devolatization, nucleation, chemical reactions, surface tension and surface roughness. This modeling can only be achieved after a series of numerical computations are combined with validation experiments. It also appears necessary that new numerical damping factors must be developed for ICFD in order to account for the new physics added to the problem with the attendant mathematical stiffness difficulties. Author

N87-20227*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGH SPEED VISCOUS FLOW CALCULATIONS ABOUT COMPLEX CONFIGURATIONS
DENNY S. CHAUSSEE *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 18 p Nov. 1986
Avail: NTIS HC A19/MF A01 CSCL 01A

A review of past parabolized Navier-Stokes applications is presented. The equations, boundary conditions, the numerical method and the grid generation are all discussed. Results ranging from the low supersonic regime to the hypersonic regime are included. Author

N87-20228*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC NAVIER-STOKES WING SOLUTION USING A ZONAL APPROACH. PART 1: SOLUTION METHODOLOGY AND CODE VALIDATION
J. FLORES, T. L. HOLST, UNVER KAYNAK (Sterling Software, Palo Alto, Calif.), K. GUNDY, and S. D. THOMAS *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986 Previously announced as N86-29765
Avail: NTIS HC A19/MF A01 CSCL 01A

A fast diagonalized Beam-Warming algorithm is coupled with a zonal approach to solve the three dimensional Euler/Navier-Stokes equations. The computer code, called Transonic Navier-Stokes (TNS), uses a total of four zones for wing configurations (or can be extended to complete aircraft configurations by adding zones). In the inner blocks near the wing surface, the thin-layer Navier-Stokes equations are solved, while in the outer two blocks the Euler equations are solved. The diagonal algorithm yields a speedup of as much as a factor of 40 over the original algorithm/zonal method code. The TNS code, in addition, has the capability to model wind tunnel walls. Transonic viscous solutions are obtained on a 150,000-point mesh for a NACA 0012 wing. A three-order-of-magnitude drop in the L2-norm of the residual requires approximately 500 iterations, which takes about 45 min of CPU time on a Cray-XMP processor. Simulations are also conducted for a different geometrical wing called WING C. All cases show good agreement with experimental data. Author

N87-20229*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC NAVIER-STOKES WING SOLUTIONS USING A ZONAL APPROACH. PART 2: HIGH ANGLE-OF-ATTACK SIMULATION
NEAL M. CHADERJIAN *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 9 p Nov. 1986 Previously announced as N86-32392
Avail: NTIS HC A19/MF A01 CSCL 01A

A computer code is under development whereby the thin-layer Reynolds-averaged Navier-Stokes equations are to be applied to realistic fighter aircraft configurations. This transonic Navier-Stokes code (TNS) utilizes a zonal approach in order to treat complex geometries and satisfy in-core computer memory constraints. The zonal approach was applied to isolated wing geometries in order to facilitate code development. The TNS finite difference algorithm, zonal methodology, and code validation with experimental data is addressed. Also addressed are some numerical issues such as code robustness, efficiency, and accuracy at high angles of attack. Special free-stream-preserving metrics proved an effective way to treat H-mesh singularities over a large range of severe flow conditions, including strong leading edge flow gradients, massive shock induced separation, and stall. Furthermore, lift and drag coefficients were computed for a wing up through CLmax. Numerical oil flow patterns and particle trajectories are presented both for subcritical and transonic flow. These flow simulations are rich with complex separated flow physics and demonstrate the efficiency and robustness of the zonal approach. Author

N87-20231*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
NUMERICAL SIMULATION OF THE FLOW FIELD AROUND A COMPLETE AIRCRAFT
J. S. SHANG and S. J. SCHERR *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 11 p Nov. 1986 Sponsored by NASA
Avail: NTIS HC A19/MF A01

The present effort represents a first attempt of numerical simulation of the flow field around a complete aircraft-like, lifting configuration utilizing the Reynolds averaged Navier-Stokes equations. The numerical solution generated for the experimental aircraft concept X24C-10D at a Mach number of 5.95 not only exhibited accurate prediction of detailed flow properties but also of the integrated aerodynamic coefficients. In addition, the present analysis demonstrated that a page structure of data collected into

cyclic blocks is an efficient and viable means for processing the Navier-Stokes equations on the CRAY XMP-22 computer with external memory device. Author

N87-20232*# Titan Systems, Inc., Princeton, N.J.
THE EFFECT OF HEAVY RAIN ON AN AIRFOIL AT HIGH LIFT
COLEMAN DUP. DONALDSON and ROGER D. SULLIVAN Mar. 1987 36 p
(Contract NAS1-18088)
(NASA-CR-178248; NAS 1.26:178248; ARAP-597) Avail: NTIS HC A03/MF A01 CSCL 01A

No serious studies of the relationship of heavy rain to aircraft safety were made until 1981 when it was suggested that the torrential rain which often occurs at the time of severe wind shear might substantially increase the danger to aircraft operating at slow speeds and high lift in the vicinity of airports. While these data were not published until early 1983, appropriate measures were taken by NASA to study the effect of heavy rain on the lift of wings typical of commercial aircraft. One of the aspects of these tests that seemed confirmed by the data was the existence of a velocity effect on the lift data. The data seemed to indicate that when all the normal non-dimensional aerodynamic parameters were used to sort out the data, the effect of velocity was not accounted for, as it usually is, by the effect of dynamic pressure. Indeed, the measured lift coefficients at high lift indicated a dropoff in lift coefficient for the same free-stream water content as velocity was increased. indicated a drop-off in lift coefficient for the same free-stream water content as velocity was increased. Author

N87-20233*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INVESTIGATION OF LEADING-EDGE FLAP PERFORMANCE ON DELTA AND DOUBLE-DELTA WINGS AT SUPERSONIC SPEEDS
PETER F. COVELL, RICHARD M. WOOD, and DAVID S. MILLER Apr. 1987 125 p
(NASA-TP-2656; L-16143; NAS 1.60:2656) Avail: NTIS HC A06/MF A01 CSCL 01A

An investigation of the aerodynamic performance of leading-edge flaps on three clipped delta and three clipped double-delta wing planforms with aspect ratios of 1.75, 2.11, and 2.50 was conducted in the Langley Unitary Plan Wind Tunnel at Mach numbers of 1.60, 1.90, and 2.16. A primary set of fullspan leading-edge flaps with similar root and tip chords were investigated on each wing, and several alternate flap planforms were investigated on the aspect-ratio-1.75 wings. All leading-edge flap geometries were effective in reducing the drag at lifting conditions over the range of wing aspect ratios and Mach numbers tested. Application of a primary flap resulted in better flap performance with the double-delta planform than with the delta planform. The primary flap geometry generally yielded better performance than the alternate flap geometries tested. Trim drag due to flap-induced pitching moments was found to reduce the leading-edge flap performance more for the delta planform than for the double-delta planform. Flow-visualization techniques showed that leading-edge flap deflection reduces crossflow shock-induced separation effects. Finally, it was found that modified linear theory consistently predicts only the effects of leading-edge flap deflection as related to pitching moment and lift trends. Author

N87-20234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR REALISTIC AIRCRAFT CONFIGURATIONS
JOHN T. BATINA, DAVID A. SEIDEL, SAMUEL R. BLAND, and ROBERT M. BENNETT Mar. 1987 22 p Presented at the AIAA/ASME/ASCE/AHS 28th Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987
(NASA-TM-89120; NAS 1.15:89120; AIAA-87-0850) Avail: NTIS HC A02/MF A01 CSCL 01A

A transonic unsteady aerodynamic and aeroelasticity code has been developed for application to realistic aircraft configurations. The new code is called CAP-TSD which is an acronym for Computational Aeroelasticity Program - Transonic Small Disturbance. The CAP-TSD code uses a time-accurate approximate factorization (AF) algorithm for solution of the unsteady transonic small-disturbance equation. The AF algorithm is very efficient for solution of steady and unsteady transonic flow problems. It can provide accurate solutions in only several hundred time steps yielding a significant computational cost savings when compared to alternative methods. The new code can treat complete aircraft geometries with multiple lifting surfaces and bodies including canard, wing, tail, control surfaces, launchers, pylons, fuselage, stores, and nacelles. Applications are presented for a series of five configurations of increasing complexity to demonstrate the wide range of geometrical applicability of CAP-TSD. These results are in good agreement with available experimental steady and unsteady pressure data. Calculations for the General Dynamics one-ninth scale F-16C aircraft model are presented to demonstrate application to a realistic configuration. Unsteady results for the entire F-16C aircraft undergoing a rigid pitching motion illustrated the capability required to perform transonic unsteady aerodynamic and aeroelastic analyses for such configurations. Author

N87-20236*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INVESTIGATION OF TRANSONIC REGION OF HIGH DYNAMIC RESPONSE ENCOUNTERED ON AN ELASTIC SUPERCRITICAL WING
DAVID A. SEIDEL, CLINTON V. ECKSTROM, and MAYNARD C. SANDFORD Mar. 1987 13 p Presented at the AIAA/ASME/ASCE/-AHS 28th Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987
(NASA-TM-89121; NAS 1.15:89121; AIAA-87-0735-CP) Avail: NTIS HC A02/MF A01 CSCL 01A

Unsteady aerodynamic data were measured on an aspect ratio 10.3 elastic supercritical wing while undergoing high dynamic response above a Mach number of 0.90. These tests were conducted in the NASA Langley Transonic Dynamics Tunnel. A previous test of this wing predicted an unusual instability boundary based on subcritical response data. During the present test no instability was found, but an angle of attack dependent narrow Mach number region of high dynamic wing response was observed over a wide range of dynamic pressures. The effect on dynamic wing response of wing angle of attack, static outbound control surface deflection and a lower surface spanwise fence located near the 60 percent local chordline was investigated. The driving mechanism of the dynamic wing response appears to be related to chordwise shock movement in conjunction with flow separation and reattachment on both the upper and lower surfaces. Author

N87-20239*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
DEVELOPMENT OF A ROTOR WAKE/VORTEX MODEL. VOLUME 2: USER'S MANUAL FOR COMPUTER PROGRAM Final Report
R. K. MAJJIGI and P. R. GLIEBE Jun. 1984 86 p
(Contract NAS3-23681)
(NASA-CR-174850-VOL-2; NAS 1.26:174850-VOL-2) Avail: NTIS HC A05/MF A01 CSCL 01A

The principal objective was to establish a verified rotor wake/vortex model for specific application to fan and compressor rotor-stator interaction and resulting noise generation. A description and flow chart of the Rotor Wake/Vortex Model computer program, a listing of the program, definitions of the input/output parameters, a sample input/output case, and input files for Rotor 55, the JT15D rotor, and Rotor 67, Stage 1 are provided. Author

N87-20240*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPIN-TUNNEL INVESTIGATION OF A 1/15-SCALE MODEL OF AN AUSTRALIAN TRAINER AIRPLANE
JAMES S. BOWMAN, JR., RAYMOND D. WHIPPLE, and WILLIAM L. WHITE May 1987 40 p
(NASA-TM-89049; L-16191; NAS 1.15:89049) Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation was conducted in the Langley Spin Tunnel of the spin and spin-recovery characteristics of a 1/15-scale model of an Australian trainer airplane. The invesigation included erect and inverted spins; configuration variables such as a long tail, fuselage strakes, 20 deg. elevator cutouts, and rudder modifications; and determination of the parachute size for emergency spin recovery. Also included in the investigation were wing leading-edge modifications to evaluate Reynolds number effects. Results indicate that the basic configuration will spin erect at an angle of attack of about 63 deg. at about 2 to 2.3 seconds per turn. Recovery from this spin was unsatisfactory by rudder reversal or by rudder reversal and ailerons deflected to full with the spin. The elevators had a pronounced effect on the recovery characteristics. The elevators-down position was very adverse to recoveries, whereas the elevators-up position provided favorable recovery effects. Moving the vertical tail aft (producing a long tail configuration) improved the spin characteristics, but the recoveries were still considered marginal. An extension to the basic rudder chord and length made a significant improvement in the spin and recovery characteristics. Satisfactory recoveries were obtained by deflecting the rudder to full against the spin and the elevators and ailerons to neutral. Author

N87-20242*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION OF TRANSONIC VISCOUS WING AND WING-FUSELAGE FLOWS USING ZONAL METHODS
JOLEN FLORES Mar. 1987 69 p
(NASA-TM-89421; A-87066; NAS 1.15:89421) Avail: NTIS HC A04/MF A01 CSCL 01A

The thin-layer Navier-Stokes equations are coupled with a zonal scheme (or domain-decomposition method) to develop the Transonic Navier-Stokes (TNS) wing-alone code. The TNS has a total of 4 zones and is extended to a total of 16 zones for the wing-fuselage version of the code. Results are compared on the Cray X-MP-48 and compared with experimental data. Author

N87-20245# Naval Surface Weapons Center, Silver Spring, Md.
SURFACE PRESSURE MEASUREMENTS ON A DOUBLE DELTA WING/BODY CONFIGURATION AT MACH 2 AND MACH 3 (WTR 1396) Wind Tunnel Data Report, 25 Feb. - 1 Mar. 1984
DONALD W. AUSHERMAN Jun. 1986 102 p
(AD-A175951; NSWC/MP/86-240) Avail: NTIS HC A06/MF A01 CSCL 20D

The surface pressures on a clipped double-delta wing/body configuration were measured at Mach 2 and Mach 3 in the Naval Surface Weapons Center (NSWC) Supersonic Tunnel Number Two at angles-of-attack up to 20 deg. The winged-body model configuration has a 2-inch diameter body consisting of a 3-caliber tangent-ogive nose and and a 7-caliber cylindrical afterbody. The wing was a clipped double-delta configuration. The body had 91 pressure taps located at various axial and circumferential locations, and the wing had 47. Surface pressures were measured at several angles-of-attack for various model roll positions at both Mach 2 and Mach 3. GRA

N87-20246# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA MECHANICA SINICA (SELECTED ARTICLES)
LIN BINGQIU and GAO ZHI 6 Jan. 1987 42 p Transl. into ENGLISH from Lixue Xuebao (China), v. 18, no. 8, May 1986 p 200-207; 215-225
(AD-A176240; FTD-ID(RS)T-1152-86) Avail: NTIS HC A03/MF A01 CSCL 20D

Based on the Navier Stokes equations, the compressible viscous vortex equation for decribing the separated vortex of an aircraft is derived and a numerical method suitable for subsonic, transonic and supersonic flows is given which can compute the characteristics of separated vortex or trailing vortex. The break-down condition of the compressible separated vortex is derived and used to compute the break-down point. The principle of flow velocity and flow pattern measurements using Doppler-frequency shifted absorption (or emission) spectral lines as well as Doppler frequency shifted and deformational nonsaturated spectral line shapes is discussed. For the case of gas flow with simultaneously inhomogeneously and homogeneously broadened line, the general expressions of non-saturation spectral line-shaped and Doppler-frequency shifted spectral line are presented. GRA

N87-20247# Bristol Univ. (England). Dept. of Aeronautical Engineering.
INVESTIGATION OF FLOW UNDER THE FUSELAGE OF A POWERED LIGHT AIRCRAFT MODEL B.S. Thesis
S. A. SMITH and R. J. WILLIAMS Jun. 1986 57 p
(BU-351; ETN-87-99212) Avail: NTIS HC A04/MF A01

The airflow under the fuselage of a scale model of the ARV Super 2 light aircraft was investigated to model the flow development in the slipstream of a propeller, particularly flow characteristics at the position of the aircraft's radiator duct. Results at simulated conditions of cruise, climb, and ground run were produced to explain cooling problems experienced in flight testing of the full size aircraft. A significant increase of static pressure across the duct is shown to occur in flight conditions, this being a probable cause of cooling inefficiency. Measurement of velocity profiles shows no evidence of effects on cooling. Flow visualization indicates propeller swirl which may also affect cooling flow by interaction with external fittings on the fuselage. The model was used to verify the choice of position for the aircraft static holes. ESA

N87-20248# Royal Air Force Coll., Cranwell (England). Dept. of Transport Technology.
THE AERODYNAMIC EFFECTS OF A SERRATED STRIP NEAR THE LEADING EDGE OF AN AIRFOIL M.S. Thesis
R. A. BARKER 1986 139 p
(ETN-87-99480) Avail: NTIS HC A07/MF A01

The aerodynamic effects of fixing a serrated strip near the leading edge, forward of the stagnation point at high incidence, was investigated using 2 airfoil models, both of 254 mm chord, but of different sections. The aerodynamic force and moment coefficients were determined for the basic and modified airfoils. The devices tested improve the maximum lift of a NACA 65(1)-212 section by up to 16% without drag penalties. However, they degrade the performance of an NLF(1)-0416 section. All leading-edge devices tested generate vortices which stream around the airfoil leading edge and over the suction surface. On the NACA airfoil only, these vortices reduce the extent of local separation near the leading edge and re-energize the turbulent boundary layer, thus delaying the onset of trailing edge separation. ESA

N87-20249# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de l'Aerodynamique.
STUDY OF THE UNSTEADY PRESSURE FIELD ON THE RA16SC1 PROFILE IN VIBRATING CONDITION [ETUDE DU CHAMP DE PRESSION INSTATIONNAIRE SUR LE PROFIL RA16SC1 EN REGIME DE TREMBLEMENT A S3MA]
B. BENOIT Jun. 1986 48 p In FRENCH
(Contract STPA-85-95-009)
(ONERA-RTS-17/3423-AY; ETN-87-99385) Avail: NTIS HC A03/MF A01

Transonic flow wind tunnel tests were carried out to test two bidimensional flow characteristics of a supercritical profile. Results show that after the onset of separation the flow becomes unstable. A coupling between the shock wave and the separation is formed. Severe pressure fluctuations are measured. Their frequency for a given Mach number increases with the incidence. The analysis indicates that the reconstitution of unsteady forces from measurements of pressure fields is feasible. ESA

N87-20250# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de l'Aerodynamique.
WING-NACELLE INTERACTIONS. PROGRAM 1985. PART TWO: DEVELOPMENT OF A FINITE ELEMENT CODE FOR AN ISOLATED NACELLE [INTERACTION NACELLE-VOILURE. TRAVAUX 85. PARTIE 2: MISE AU POINT D'UN CODE D'ELEMENTS FINIS POUR UNE NACELLE ISOLEE]
J. MARECHAL Jul. 1986 60 p In FRENCH
(Contract STPA-85-95-009)
(ONERA-RTS-21/3271-AY; ETN-87-99386) Avail: NTIS HC A04/MF A01

The computation of three dimensional unsteady transonic flow around an isolated nacelle is studied. A finite element code was used to solve the complete potential equation in its conservative form. The potential equation is discretized using an H mesh and the linearization is made using a fixed point method. A gradient algorithm coupled to Cholesky factorization solves the problem accelerating the convergence. The results of three complete flow computations are included. ESA

N87-20251# Centre d'Etudes Aerodynamiques et Thermiques, Poitiers (France). Lab. d'Etudes Thermodynamiques.
STUDY OF COMPRESSIBILITY EFFECTS ON SUPERSONIC FREE FLOW Final Report [ETUDE DES EFFETS DE COMPRESSIBILITE SUR LES ECOULEMENTS LIBRES SUPERSONIQUES]
J. P. BONNET Jun. 1986 35 p In FRENCH
(Contract DRET-84-057)
(ETN-87-99392) Avail: NTIS HC A03/MF A01

Following a study characterizing flow and wake at Mach 2, the supersonic effects at Mach 3 are studied. Wind tunnel tests were carried out and the space distribution of the axial velocity variations were determined. The calibrating methods are described. The results of the turbulence measurements, as well as numerical simulation results are presented. The average velocities evolve towards a classical asymptotic state associated to an evolution of the virtual origin which increases with the Mach number. ESA

N87-20966*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
IN-FLIGHT SURFACE OIL-FLOW PHOTOGRAPHS WITH COMPARISONS TO PRESSURE DISTRIBUTION AND BOUNDARY-LAYER DATA
ROBERT R. MEYER, JR. and LISA A. JENNETT Apr. 1985 27 p Original contains color illustrations
(NASA-TP-2395; H-1184; NAS 1.60:2395) Avail: NTIS HC A03/MF A01 CSCL 01A

Upper surface oil-flow photographs were obtained at transonic speeds on an F-111 transonic aircraft technology (TACT) aircraft, which had been fitted with a natural laminar-flow airfoil section. The oil-flow photographs were interpreted with regard to shock and boundary-layer characteristics and compared to results obtained from pressure distributions and boundary-layer measurements. Results indicated that flow phenomena (such as shock location and strength) and chord location of boundary-layer characteristics (such as transition location) could be correctly identified from the oil-flow photographs. Author

N87-20973# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ACTIVITIES REPORT IN AERODYNAMICS Annual Report, 1985
Oct. 1986 53 p Original contains color illustrations
(ETN-87-99372) Avail: NTIS HC A04/MF A01

Development of a panel method for complex configurations analyses; solution of the Euler equations; computation of massively separated flows by numerical viscid-inviscid interaction methods; calculation of the boundary layer-shock wave interaction in supersonic flow by a viscous-inviscid interaction numerical method shock wave - turbulent boundary layer interaction in three-dimensional channel flow; solution of the Navier-Stokes equations in compressible flow; modeling of turbulence in transonic interactions; computed evolution of a homogenous turbulence subjected to rotation effects; attractors for two-dimensional incompressible viscous flows; separations around different types of wings and fuselages; a wing section for light aircraft; profiles for helicopter blades; pressure distributions on flight-tested rotor blades; high-lift configurations; flow around a nacelle/pylon/wing system; unsteady pressure field in separated flow; flow in a three-dimensional air duct; flow through a cascade at high Reynolds number; the longitudinal aerodynamic characteristics of a missile; performance of the ejector of an altitude simulation test bench; ultralight wall wind tunnel; and a high frequency gust generator are discussed. ESA

N87-20974# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
LA RECHERCHE AEROSPATIALE, BIMONTHLY BULLETIN, NUMBER 1986-2, 231/MARCH-APRIL
CLAUDE SEVESTRE, ed. Nov. 1986 86 p Transl. by ONERA into ENGLISH of 'La Recherche Aerospatiale, Bulletin Bimestriel (Paris), No. 1986-2, 231/Mar.-Apr. 1986"
(ESA-TT-998; ETN-87-99429) Avail: NTIS HC A05/MF A01; print copy in ENGLISH available at ONERA, Paris, France FF75; original report in FRENCH available at ONERA, Paris, France FF75

Analysis of velocity potential around intersecting bodies; a finite element program in cyclic viscoplasticity; functional reduction of stochastic fields for studying stationary random vibrations; dynamical vibrations of rotating laminated composite structures; numerical determination of the dynamic characteristics of a composite blade; reduction of turbulent skin friction via turbulence moderators; and a method for analyzing four-hot-wire probe measurements are discussed. ESA

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A87-31488
REDUCTIONS IN OCEANIC SEPARATION STANDARDS THROUGH THE USE OF A TCAS-DERIVED CDTI
W. DWIGHT LOVE and ALVIN L. MCFARLAND (Mitre Corp., McLean, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 294-301. refs

This paper presents a concept for using a Cockpit Display of Traffic Information (CDTI), as derived from a modified version of the Traffic Alert and Collision Avoidance System II (TCAS II), to

support reductions in air traffic separation minima for an oceanic track system. The motivation for this concept is to increase fuel efficiency for aircraft flying transoceanic routes. The concept is described, the feasibility of the concept is examined from a number of standpoints, and pilot procedures for dealing with alert situations are discussed. It is concluded that the concept is feasible, but additional development and experimentation is required before implementation. Author

A87-31489
WINDSHEAR DETECTION/ALERT AND GUIDANCE COCKPIT DISPLAYS - A PILOT'S PERSPECTIVE
JOHN B. RILEY (Sperry Corp., Phoenix, AZ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 302-306.

It is becoming more apparent that windshear as a flight hazard is much more prevalent than was once thought. As a result of several accidents and incidents over the last few years resulting in a significant loss of life, the aviation industry and the FAA have begun an intense program to study the phenomenon and develop programs to alleviate the problem. Airborne detection/alert and guidance systems are being developed by many of the aircraft equipment manufacturers. This paper explores how the fact of a detected windshear such as a downburst should be depicted to the pilot including warning lights, aural warnings and angle of attack presentations, as well as flight guidance information to be used in the escape maneuver on the Flight Director Displays. Author

A87-31698
MEDICAL HELICOPTERS - CARBON MONOXIDE RISK?
THOMAS J. POULTON (Creighton University, Omaha, NE) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 58, Feb. 1987, p. 166-168. refs

Carbon monoxide exposure of medical personnel working beneath the turning rotor of a medical helicopter appeared to cause mild clinical illness. The carbon monoxide levels were measured in various locations beneath the rotor of a jet helicopter under two different conditions. Carbon monoxide levels ranged from 8-76 ppm depending on location of sampling and speed of operation of the engine. This level of carbon monoxide is potentially a problem, as is the inhalation of jet fuel vapor, when working beneath the rotors of an operating helicopter. Author

A87-32163#
LOCAL HEAT-TRANSFER COEFFICIENTS OF SIMULATED SMOOTH GLAZE ICE FORMATIONS ON A CYLINDER
MARTIN PAIS and S. N. SINGH (Kentucky, University, Lexington) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 1, April 1987, p. 117-121. Previously cited in issue 21, p. 3042, Accession no. A85-43873. refs

A87-32576
AIRCRAFT FIRE SAFETY OVERVIEW
LIONEL C. VIRR (Civil Aviation Authority, London, England) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 6 p.
(SAE PAPER 861617)

A survey is presented of current aircraft design techniques for minimizing fire risks inside passenger aircraft. The discussion covers engine, fuel and oxygen supply fire suppression and inhibition techniques, leak and fire detection systems, and precautions which are necessary when composite materials are used. Improvements in fire-hardened materials for furnishing passenger compartments are noted, along with continuous efforts to upgrade in-service fire control procedures, albeit with new procedures defined after disastrous fires have occurred. Interactions between design efforts and the certification process are explored. It is noted that aircraft technology enhancements, such as fully digital engine control, introduce hazards which may not become apparent until many hours of operational use have accumulated. M.S.K.

A87-33054
OBSTACLES TO MEETING ARMY NATIONAL GUARD AVIATOR TRAINING REQUIREMENTS
SANDRA M. SZABO, JOHN W. RUFFNER, KENNETH D. CROSS (Anacapa Sciences, Inc., Fort Rucker, AL), and MICHAEL G. SANDERS (U.S. Army, Aviation Research and Development Activity Institute, Fort Rucker, AL) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 1052-1055.

Army National Guard (ARNG) aviators must meet the same aviation training requirements as active Army aviators. During the past 10 years, the training requirements have increased significantly; yet, the amount of time allocated for ARNG aviators to meet the requirements has remained relatively constant. To determine if the aviators need additional allocated training time, a questionnaire survey was conducted. One objective of the survey was to identify the types of obstacles that interfere with the aviators' ability to meet the training requirements. The results indicate that five factors pose major problems to meeting the aviators' continuation training requirements. The factors are an Insufficient Number of Flight Hours, Unavailability of Instructor Pilots, Unavailability of Training Support Areas, Unavailability of Support Equipment, and an Insufficient Amount of Personal Time. The identification of time related obstacles supports the aviators' perceptions that additional training time is needed; however, the identification of obstacles that are not time related suggests that remedial actions, in addition to an increase in training time, can be taken. Author

A87-34569*# Defense Nuclear Agency, Washington, D.C.
DESCRIPTION OF AN AIRCRAFT LIGHTNING AND SIMULATED NUCLEAR ELECTROMAGNETIC PULSE (NEMP) THREAT BASED ON EXPERIMENTAL DATA
PEDRO L. RUSTAN, JR. (DNA, Alexandria, VA) IEEE Transactions on Electromagnetic Compatibility (ISSN 0018-9375), vol. EMC-29, Feb. 1987, p. 49-63. USAF-FAA-Navy-NASA-supported research. refs

Lightning data obtained by measuring the surface electromagnetic fields on a CV-580 research aircraft during 48 lightning strikes between 1500 and 18,000 feet in central Florida during the summers of 1984 and 1985, and nuclear electromagnetic pulse (NEMP) data obtained by surface electromagnetic field measurements using a 1:74 CV-580 scale model, are presented. From one lightning event, maximum values of 3750 T/s for the time rate of change of the surface magnetic flux density, and 4.7 kA for the peak current, were obtained. From the simulated NEMP test, maximum values of 40,000 T/s for the time rate of change of the surface magnetic flux density, and 90 A/sq m for the total normal current density, were found. The data have application to the development of a military aircraft lightning/NEMP standard. R.R.

A87-34766
SOVIETS LEARN WIDEBODY LESSONS
VLADIMIR MEZOK Flight International (ISSN 0015-3710), vol. 131, Feb. 21, 1987, p. 24-26.

The critique of the new Il-86 widebody airliner's cockpit technologies and general handling qualities recently published in the Soviet Union by Vladimir C. Mezok is discussed. It is noted by Mezok that the geometry and greater weight of widebody aircraft lead to a substantial increase in moment of inertia, with consequent delay in control response; the use of a flight engineer control-based procedure for speed determination during landing approach, which is exacerbated by an unusually low thrust-to-weight ratio and slow throttle response, is also criticized. Attention is given to Il-86 dimensional and performance data vis-a-vis the Tu-154 and DC-10-10 airliners, as well as to its high angle-of-attack wing aerodynamics. O.C.

N87-20252*# Mesoscale Environmental Simulations, Inc., Hampton, Va.
THE TERMINAL AREA SIMULATION SYSTEM. VOLUME 2: VERIFICATION CASES
F. H. PROCTOR Washington NASA Apr. 1987 112 p
(Contract NAS1-17409)
(NASA-CR-4047-VOL-2; NAS 1.26:4047-VOL-2; DOT/FAA/PM-86/50-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 01C

The numerical simulation of five case studies are presented and are compared with available data in order to verify the three-dimensional version of the Terminal Area Simulation System (TASS). A spectrum of convective storm types are selected for the case studies. Included are: a High-Plains supercell hailstorm, a small and relatively short-lived High-Plains cumulonimbus, a convective storm which produced the 2 August 1985 DFW microburst, a South Florida convective complex, and a tornadic Oklahoma thunderstorm. For each of the cases the model results compared reasonably well with observed data. In the simulations of the supercell storms many of their characteristic features were modeled, such as the hook echo, BWER, mesocyclone, gust fronts, giant persistent updraft, wall cloud, flanking-line towers, anvil and radar reflectivity overhang, and rightward veering in the storm propagation. In the simulation of the tornadic storm a horseshoe-shaped updraft configuration and cyclic changes in storm intensity and structure were noted. The simulation of the DFW microburst agreed remarkably well with sparse observed data. The simulated outflow rapidly expanded in a nearly symmetrical pattern and was associated with a ringvortex. A South Florida convective complex was simulated and contained updrafts and downdrafts in the form of discrete bubbles. The numerical simulations, in all cases, always remained stable and bounded with no anomalous trends. Author

N87-20253*# Analytical Mechanics Associates, Inc., Mountain View, Calif.
DESIGN AND ANALYSIS OF ADVANCED FLIGHT PLANNING CONCEPTS Final Report
JOHN A. SORENSEN Washington NASA Mar. 1987 153 p
(Contract NAS1-17345)
(NASA-CR-4063; NAS 1.26:4063; AMA-85-09) Avail: NTIS HC A08/MF A01 CSCL 01C

The objectives of this continuing effort are to develop and evaluate new algorithms and advanced concepts for flight management and flight planning. This includes the minimization of fuel or direct operating costs, the integration of the airborne flight management and ground-based flight planning processes, and the enhancement of future traffic management systems design. Flight management (FMS) concepts are for on-board profile computation and steering of transport aircraft in the vertical plane between a city pair and along a given horizontal path. Flight planning (FPS) concepts are for the pre-flight ground based computation of the three-dimensional reference trajectory that connects the city pair and specifies the horizontal path, fuel load, and weather profiles for initializing the FMS. As part of these objectives, a new computer program called EFPLAN has been developed and utilized to study advanced flight planning concepts. EFPLAN represents an experimental version of an FPS. It has been developed to generate reference flight plans compatible as input to an FMS and to provide various options for flight planning research. This report describes EFPLAN and the associated research conducted in its development. Author

N87-20254*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TRAFFIC SCENARIO GENERATION TECHNIQUE FOR PILOTED SIMULATION STUDIES
DAVID H. WILLIAMS and DOUGLAS C. WELLS (Embry-Riddle Aeronautical Univ., Daytona Beach, Fla.) Apr. 1985 46 p
(NASA-TM-86397; NAS 1.15:86397) Avail: NTIS HC A03/MF A01 CSCL 01C

Piloted simulation studies of cockpit traffic display concepts require the development of representative traffic scenarios. With the exception of specific aircraft interaction issues, most research questions can be addressed using traffic scenarios consisting of prerecorded aircraft movements merged together to form a desired traffic pattern. Prerecorded traffic scenarios have distinct research advantages, allowing control of traffic encounters with repeatability of scenarios between different test subjects. A technique is described for generation of prerecorded jet transport traffic scenarios suitable for use in piloted simulation studies. Individual flight profiles for the aircraft in the scenario are created interactively with a computer program designed specifically for this purpose. The profiles are then time-correlated and merged into a complete scenario. This technique was used to create traffic scenarios for the Denver, Colorado area with operations centered at Stapleton International Airport. Traffic scenarios for other areas may also be created using this technique, with appropriate modifications made to the navigation fix locations contained in the flight profile generation program. Author

N87-20255*# Mesoscale Environmental Simulations, Inc., Hampton, Va.
THE TERMINAL AREA SIMULATION SYSTEM. VOLUME 1: THEORETICAL FORMULATION
F. H. PROCTOR Washington NASA Apr. 1987 168 p
Prepared in cooperation with SASC Technologies, Inc., Hampton, Va.
(Contract NAS1-17409)
(NASA-CR-4046-VOL-1; NAS 1.26:4046-VOL-1; DOT/FAA-PM-86/50-VOL-1) Avail: NTIS HC A08/MF A01 CSCL 01C

A three-dimensional numerical cloud model was developed for the general purpose of studying convective phenomena. The model utilizes a time splitting integration procedure in the numerical solution of the compressible nonhydrostatic primitive equations. Turbulence closure is achieved by a conventional first-order diagnostic approximation. Open lateral boundaries are incorporated which minimize wave reflection and which do not induce domain-wide mass trends. Microphysical processes are governed by prognostic equations for potential temperature water vapor, cloud droplets, ice crystals, rain, snow, and hail. Microphysical interactions are computed by numerous Orville-type parameterizations. A diagnostic surface boundary layer is parameterized assuming Monin-Obukhov similarity theory. The governing equation set is approximated on a staggered three-dimensional grid with quadratic-conservative central space differencing. Time differencing is approximated by the second-order Adams-Bashforth method. The vertical grid spacing may be either linear or stretched. The model domain may translate along with a convective cell, even at variable speeds. Author

N87-20256# Bristol Univ. (England). Dept. of Aeronautical Engineering.
A PRELIMINARY STUDY INTO THE CONSTANT DRAG PARACHUTE FOR AIRCREW ESCAPE SYSTEMS B.S. Thesis
P. D. MARSHALL and R. B. MUSTARDE Jun. 1986 61 p
(BU-345; ETN-87-99207) Avail: NTIS HC A04/MF A01

Parachute geometries for use in high velocity, low altitude ejections, to maximize the survivability of such situations by creating a system which maintains a high level of deceleration were studied in a low speed wind tunnel, the forces in the streamwise direction during and after initial inflation being recorded for each test. The limitations of such testing were also noted. Variable geometry parachutes, possibly of the reefed type, are shown to have potential to be highly efficient at maintaining drag levels. The ideal system would employ a parachute of this type, coupled with an energy absorbing mechanism, parachute expansion being controlled via a force sensor built into the seat. ESA

N87-20975 Civil Aviation Authority, London (England).
GROUND DE-ICING OF AIRCRAFT
Dec. 1985 20 p
(CAP-512; ISBN-0-86039-265-1; ETN-87-99497) Avail: Issuing Activity

Maintenance and operational aspects of ground deicing of aircraft are discussed. Practices for safe cold weather operations are outlined. Conditions conducive to aircraft icing; and the effects of ice, snow, and frost accretions on aircraft performance and flight characteristics are described. ESA

N87-20976 Civil Aviation Authority, London (England).
EXTENDED RANGE TWIN OPERATIONS (ETOPS)
Jan. 1986 34 p
(CAP-513; ISBN-086039-267-8; ETN-87-99498) Avail: Issuing Activity

Acceptable means (but not necessarily the only means) by which approval may be given for UK-registered twin-engined airplanes to operate over a route that contains a point further than 1hr flying time (in still air) at the normal one-engine-inoperative cruise speed from an adequate aerodrome are described. The requirements apply to all twin-engined airplanes (including those powered by turboprops and reciprocating engines) flying for public transport, whose maximum authorized take-off weight exceeds 5700 lgs; and if the airplane is certificated to carry more than 19 passengers. ESA

N87-20980# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 14, 1985 ACCIDENTS
15 Sep. 1986 409 p
(PB86-916928; NTSB-AAB-86-28) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent HC $185.00/year, all others write for quote CSCL 01C

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A87-31457
AERONAUTICAL SATELLITE COMMUNICATIONS OVER THE ATLANTIC - A TECHNICAL DEMONSTRATION
GEORGE A. COBLEY (Rockwell International Corp., Cedar Rapids, IA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 61-68. refs

In August 1985 a flight demonstration of a civilian experimental satellite data link system was conducted using an aircraft that operated out of Cedar Rapids, IA to the remote areas of the Atlantic Ocean north of Reykjavik, Iceland. The flight test had four major demonstration objectives: automatic communication to an earth station of aircraft position data from GPS, two-way communication of ARINC Communications Addressing and Reporting System (ACARS) messages between the aircraft and ground, communication of weather data from the ground to the aircraft and two-way communication of air traffic control data. This paper describes the flight demonstration, the results of the tests conducted, and follow-on work supporting operational development of aeronautical satellite communications. A discussion is presented of recent industry activities relating to the establishment of an operational aeronautical satellite data communications system. Author

A87-31458#
MICROWAVE LANDING SYSTEM AREA NAVIGATION
JAMES REMER and BARRY BILLMANN (FAA, Technical Center, Atlantic City, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 69-75.

The International Civil Aviation Organization Standards and Recommended Practices states that the Time Reference Scanning Beam Microwave Landing System (MLS) will supplant the existing Instrument Landing System as the recognized international standard as early as 1995. The MLS provides the ability to determine the aircraft's position in three-dimensional space over a large coverage volume in the airport terminal area. This affords the capability to navigate and execute approaches throughout this volume of coverage. This technique is known as Microwave Landing System Area Navigation (MLS RNAV). In order to assess and further develop the potential capabilities of MLS RNAV, the FAA Technical Center has undertaken the tasks of performing analytical studies, as well as the development of a prototype MLS RNAV system. Author

A87-31468
AN INTEGRATED NAVIGATION SYSTEM FOR ADVANCED ATTACK HELICOPTERS
S. I. SNYDER (Honeywell Systems and Research Center, Minneapolis, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 150-156.

This paper determines a self-contained integrated navigation system for advanced attack helicopters. Of particular interest is the quality of the inertial navigation system needed in order to meet requirements imposed by functions such as fire control and target handoff. The requirements include a 30 meter position accuracy, 0.5 meter/sec. velocity, 0.1 degree level attitude and 0.5 degree heading accuracy. The above requirements, except for the 30 meter position requirement, can be achieved with a 0.1 degree per hour quality gyro inertial navigation system (INS) aided with a Doppler velocimeter. The 30 meter position requirement is satisfied when GPS is available. The recommended integrated navigation system for the advanced rotorcraft includes GPS, Doppler, and INS. This system will also utilize the additional update capabilities provided by target acquisition sensors (waypoint updating), PLRS (communication equipment), and terrain correlation with a digital map. Author

A87-31469
OPERATION AND PERFORMANCE OF AN INTEGRATED HELICOPTER COMMUNICATION SYSTEM
WALTER R. FRIED (Hughes Aircraft Co., Fullerton, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 157-164.

The unique operational and performance requirements of the Communication System for modern tactical Army helicopters are described. An integrated system architecture is described which satisfies these requirements and incorporates very high levels of automation thereby reducing pilot workload. The automation concepts include the use of a preloaded communication data base and a centralized communication processor containing advanced control, reconfiguration and message formatting software. Link analysis and simulation results are presented which show the performance capabilities of the system with respect to the projected mission requirements. Author

A87-31484
OPTICAL DISK TESSELLATED GEOID MANAGEMENT FOR DIGITAL MAP
EDWARD W. RONISH (Sperry Corp., Aerospace and Marine Group, Albuquerque, NM) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 257-260.

The modern pilot concurrently uses sophisticated navigational equipment and old-fashioned maps for missions sometimes covering thousands of miles and several targets. The utilization of paper maps for the duration of the mission has increasingly become a time-consuming hindrance, in view of the pilot's other responsibilities. Now it is possible to have this burden of map management shifted from the pilot to the digital map computer (DMC) and computer programmer. The digital map computer can store all the maps the pilot needs and then display them in a hands-off environment, or it can serve as a graphics workstation to allow the pilot to enter new threat and intelligence information or other overlay data. Management of the digital maps and overlays while the aircraft flies at supersonic speeds is the subject of this paper. Author

A87-31485* TAU Corp., Los Gatos, Calif.
GUIDANCE AUTOMATION FOR NAP-OF-THE-EARTH FLIGHT
RICHARD V. DENTON, NICK PEKELSMA, MINE HAGEN (TAU Corp., Los Gatos, CA), and LEONARD MCGEE (NASA, Ames Research Center, Moffett Field, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 261-266. refs
(Contract NAS2-12092)

Low-Altitude/Nap-of-the-Earth (NOE) rotorcraft flight in adverse weather has been identified as a major technology void by both military and civil agencies because of its direct relationship to the needs of the military's new scout-attack helicopter and to various civilian applications including Emergency Medical Services (EMS). As part of NASA's Aircraft Automation Program, Ames Research Center has identified as a major goal the automating and advancing of applicable terrain following/terrain avoidance/obstacle avoidance (TF/TA/OA) guidance technologies to a level where NOE rotorcraft flight can be demonstrated in an advanced simulator and, later, in fully automatic flight. Areas of emphasis to date for achieving automatic guidance include real-time sensor blending and the real-time computation of NOE guidance commands. The present paper reports on the guidance command generation. The applicability of TF/TA techniques to the NOE problem is described, and simulation results are presented that suggest that automatic NOE can indeed be accomplished. Author

A87-31486
INTEGRATED FLYING AID AND MISSION DISPLAYS FOR MODERN COMBAT AIRCRAFT INCORPORATING A DIGITAL DATA BASE
A. M. WHITEHEAD, W. P. THOMAS (Royal Aircraft Establishment, Farnborough, England), and M. P. WILKINS (GEC Avionics, Ltd., Rochester, England) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 267-274. refs

Electro-optic sensors - Forward Looking Infra Red and Night Vision Goggles - are today providing a dramatic enhancement of low level operational capability, but causing increased demands for precision navigation, situation awareness and advanced displays. Digital map displays, also available today, offer the flexibility of map presentation that is needed. In the future, terrain referenced systems incorporating digital data bases hold the promise of the integrated flying aid and mission displays that are required for 'all-weather' operations. This paper describes first the fit and usage of the EO systems likely in a future combat aircraft and goes on to review the status of data base systems. It establishes the baseline against which digital map systems and later terrain referenced displays that exploit an elevation data base might be integrated into the aircraft. Author

A87-31487#
THE DIGITAL MAP AS A TACTICAL SITUATION DISPLAY
NORMAN K. SHUPE and BARBARA BERNABE (U.S. Army, Avionics Research and Development Activity, Fort Monmouth, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 275-288. refs

A topographic map as a graphic basis for presenting tactical information is consistent with the human information processing capacity required for rapid situation assessment. The primary barrier to developing a topographically based situation display has been merging the tactical image and the topographic image on a single display surface. A digital map integrated with a modern symbol generator and airborne processing power can overcome this barrier. The airborne processor can be exploited to interpret alphanumeric tactical data and transform it to a graphic representation, while the symbol generator can inset the resulting tactical image over the topographic image. A consequence of the available flexibility of this technology is an increase in the numbers and complexity of tactical data to be managed. Thus, the ultimate utility of the resulting display depends on an efficient operator interface to facilitate interaction with data. The present paper describes the integration of a digital topographic map as a tactical data display on an OH58-D aircraft. Author

A87-31498
AI/EXPERT SYSTEM PROCESSING OF SENSOR INFORMATION
IRA GLICKSTEIN and MICHAEL CHEN (IBM, Federal Systems Div., Oswego, NY) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 382-388.

This paper focuses on higher-level post-processing, using advanced automation and artificial intelligence (AI) technologies, to better manage sensors and pre-processor resources, and improve the quality and robustness of the automatic target recognition (ATR) process. Sensor exploitation, which is the fusion of information from multiple sensors and auxiliary data sources at the system level, is a critical function for which a knowledge-based 'expert' system is currently being developed. The special requirements of intelligent airborne systems are discussed and opportunities for system-level processing are outlined. Author

A87-31522
MODE S DATA LINK - CHARACTERISTICS, CAPACITY, AND APPLICATIONS
ERNEST LUCIER (FAA, Washington, DC) and JAMES E. DIEUDONNE (Mitre Corp., McLean, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 565-570. refs

As an integral part of the Federal Aviation Administration's (FAA) new secondary surveillance radar system, the Mode S digital data link will bring new capabilities (air/ground data communications) and benefits (increased productivity, enhanced safety, and increased system capacity) to the National Airspace System (NAS) and the aviation user. This paper first describes how the 'Mode S System' works including system architecture, the ground beacon (secondary radar) system, the onboard avionics equipment, the supporting ground data link applications equipment, and the signals-in-space. The characteristics of the transmissions and communications protocols, and system capacity are defined. Next, the paper describes the initial data link services to be provided to the Mode S user and the most likely follow-on services. The paper concludes with a status report on FAA's implementation of data link and avionics standards. Author

A87-31523
ATC AIR/GROUND DIGITAL COMMUNICATIONS ARCHITECTURE ARCHITECTURE
THEODORE L. SIGNORE (Mitre Corp., McLean, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 571-578. refs
The Mode S surveillance beacon system will provide a digital discreetly addressable data link between aircraft and ground. This data link will exist in an environment in which multiple networks interoperate. The Open Systems Interconnection Reference Model is applied to determine the operating characteristics of the Mode S data link so that it is compatible with connected networks. Two protocol services, the Datagram service and the Connection service, are defined for the Mode S data link which are designed to incorporate the necessary characteristics. Author

A87-31524
MANAGING WITH THE ONBOARD DATA LINK - A PILOT'S VIEW
JOHN PAPADAKIS (United Airlines, Inc., Dunedin, FL) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 579-583. refs
The use of a data link in aircraft communications is examined from a pilot's perspective. It is argued that the use of the data link in combination with the radio telephone will help to alleviate the expectation factor and radio ambiguities. The effects of the data link on the work load of pilots and controller are studied. The application of the data link to the Automatic Terminal Information System is discussed. Some disadvantages of the data link communications are described. I.F.

A87-31533* Boeing Commercial Airplane Co., Seattle, Wash.
AVIONICS ELECTROMAGNETIC INTERFERENCE IMMUNITY AND ENVIRONMENT
C. A. CLARKE (Boeing Commercial Airplane Co., Seattle, WA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 633-640. refs
(Contract NAS2-12261)
Aircraft electromagnetic spectrum and radio frequency (RF) field strengths are charted, profiling the higher levels of electromagnetic voltages encountered by the commercial aircraft wiring. Selected military, urban, and rural electromagnetic field levels are plotted and provide a comparison of radiation amplitudes. Low frequency magnetic fields and electric fields from 400 H(Z) power systems are charted versus frequency and wire separation to indicate induced voltages on adjacent or neighboring circuits. Induced EMI levels and attenuation characteristics of electric, magnetic, RF fields, and transients are plotted and graphed for common types of wire circuits. The significance of wire circuit returns and shielding is emphasized to highlight the techniques that help block the paths of electromagnetic interference and maintain avionic interface signal quality. Author

A87-31544
APPLICATION OF GROUND/AIR DATA LINK TO GENERAL AVIATION OPERATIONS
MICHAEL A. RAGLAND (Mitre Corp., McLean, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 738-742. Research supported by the Mitre Corp.
The FAA project aimed at improving the national airspace system is discussed. The use of a low-cost portable laptop PC to provide pilots with data link services via a mode select data link is studied. The new mode select beacon system is to have an integral data link capability which provides ATC and weather services using two-way data communications. The pilot position man/machine interface development to be used for general aviation operations is examined. The hardware and software for the proposed cockpit input/output terminal are described. Pilots' reactions to the use of a lap PC input/output terminal are analyzed. I.F.

A87-32670
MAN-MACHINE AIRCRAFT-NAVIGATION COMPLEXES [NAVIGATSIONNYE ERGATICHESKIE KOMPLEKSY SAMOLETOV]
VASILII VASILEVICH KOZARUK and IAKOV IUDKOVICH REBO Moscow, Izdatel'stvo Mashinostroenie, 1986, 288 p. In Russian. refs
The efficiency of flight-safety assurance by means of man-machine navigation complexes is assessed. The statistical performance and precision criteria of such complexes are elucidated, and attention is given to questions concerning crew workloads and the automation of the navigation process. The goal of the present work is to define the level of flight safety that can be assured by a large complex man-machine (crew-aircraft) system. B.J.

A87-33030
CASE STUDY - DEVELOPING AN OPERATIONS CONCEPT FOR FUTURE AIR TRAFFIC CONTROL
ELIZABETH D. MURPHY, WILLIAM D. COLEMAN, LISA J. STEWART, and SYLVIA B. SHEPPARD (Computer Technology Associates, Inc., McLean, VA) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 585-589. refs
(Contract DOT-FA01-85-4-01008)
A task identification, sequencing, and analysis process defined the operational requirements of automated capabilities proposed to support human decision making in future air traffic control. Active and continuous user group involvement was a key feature of this process. Results indicate that information necessary for effective computer-human interaction design can be generated in the early phases of system development. Early application of structured engineering techniques and human factors methods leads to a better understanding of the proposed capabilities and to better communication between the users and designers of a system.
Author

A87-33049
RECOGNITION OF SYNTHESIZED, COMPRESSED SPEECH IN NOISY ENVIRONMENTS
DARYLE JEAN GARDNER, BRYAN BARRETT, JOHN ROBERT BONNEAU, KAREN DOUCET, PROSPER VANDERWEYDEN (Kearney State College, NE) et al. IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 927-930.
The purpose of the present study was to investigate the recognition of synthesized, compressed speech under helicopter noise vs. ambient noise conditions. Subjects performed an isolated word recognition task for stimuli generated by the VOTAN V-5000A speech synthesizer/recognizer. Results indicated that recognition performance, both in terms of percentage correct and average response time, deteriorated as a function of speech compression and level of noise. Implications of these results for the employment of compressed, synthesized speech warning systems is rotary wing aircraft are discussed. Author

A87-33052
PERFORMANCE OF THREE VISUAL APPROACH LANDING LIGHT SYSTEMS
ROBERT S. KELLOGG and DAVID C. HUBBARD (Dayton, University, Williams AFB, AZ) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 1043-1046. refs
This report documents the methodology and experimental approach taken to evaluate the effectiveness of the three visual approach landing light systems: Visual Approach Slope Indicator (VASI), Precision Approach Path Indicator (PAPI), and Pulse Light

Approach Slope Indicator (PLASI). Performance measures were taken inflight in the Air Force T-37 jet trainer, which produced objective determinations of deviations from glideslope on final approach, for each system. The subjects were experienced Air Force Instructor Pilots. Results showed that PAPI and PLASI were statistically equivalent, but that both were superior to VASI. Some subjective pilot evaluations of the free systems are also described. Author

A87-33070
RESEARCH ON SPEECH PROCESSING FOR MILITARY AVIONICS
THOMAS J. MOORE and RICHARD L. MCKINLEY (USAF, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 1331-1335. refs

The Biological Acoustics Branch of the Armstrong Aerospace Medical Research Laboratory (AAMRL) is engaged in research in a number of speech related areas. This paper describes the approach used to conduct research in the development and evaluation of military speech communication systems, mentions the types of studies done using this approach, and gives examples of the types of data generated by these studies. Representative data are provided describing acoustic-phonetic changes that occur when speech is produced under acceleration. Author

A87-33330
THE EQUIPPING OF THE AVIA-D RADAR INSTALLATION WITH A WEATHER CHANNEL AS A CONTRIBUTION TO THE MODERNIZATION OF THE RADAR COMPLEX AVIA-D/KOREN [AUSRUESTUNG DER RADARANLAGE AVIA-D MIT DEM WETTERKANAL ALS BEITRAG ZUR MODERNISIERUNG DES RADARKOMPLEXES AVIA-D/KOREN]
WISLAW KLEMBOWSKI (Przemyslowy Instytut Telekomunikacji, Warsaw, Poland) and WOLFGANG RASCHKE (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 22, no. 6, 1986, p. 209-214. In German.

The installation of a weather channel for the real-time representation of meteorological phenomena on the AVIA-D radar installation is discussed. The purpose, operational principle, general structure, and signal processing network of the channel are discussed in detail. The most important technical parameters of the channel are given, and the structure, operational principles, and technical parameters of the subsystems are presented. The channel's main function will be to help air traffic controllers detect and respond to potentially dangerous weather phenomena. C.D.

A87-33331
AUTOMATED MEASURING SYSTEM FOR ILS [AUTOMATISIERTES MESSSYSTEM FUER ILS]
CHRISTIAN HOFMANN (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin and Dresden, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 22, no. 6, 1986, p. 217-219. In German. refs

The development, functions, and instrumentation of an automated measuring system for instrument landing systems (ILS) are discussed. The operations involved in the computation, regulation of target amplitude, data storage, interference suppression and manual tracking, orientation and servocontrol, and calibration are described. The ground systems are briefly described, giving technical data. C.D.

A87-33332
SUPPLEMENTAL DATA TRANSMISSION IN AM RADIO BROADCASTING [ZUSAETZLICHE DATENUEBERTRAGUNG IM AM-HOERRUNDFUNK]
WERNER TREMPLER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 22, no. 6, 1986, p. 225-228. In German.

A procedure for the supplemental, simultaneous, and compatible transmission of digital information over AM radio in simplex operation is reported. The principle of this method and its advantages are briefly described, and the technical modifications in the AM radio transmitter and receiver are summarized. The technical parameters and coefficients are given, and proposals are made for the use of this procedure in civil aviation in East Germany. The prospects for the actual use of the procedure are addressed. C.D.

A87-33333
INSTRUMENT LANDING SYSTEMS OF TODAY AND TOMORROW - FROM ILS TO MLS [INSTRUMENTENLANDESTSTEME HEUTE UND MORGEN - VOM ILS ZUM MLS]
WERNER TREMPLER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 22, no. 6, 1986, p. 239-246. In German. refs

The microwave landing system (MLS), which is to replace the instrument landing system (ILS) on curved flight paths, is discussed in detail. The definition, functional principle, ground installations, and setting-up criteria of MLS are addressed. Preparations being undertaken for the introduction of MLS are outlined, and prospects for the full operational use of MLS are assessed. Important technical data for both MLS and ILS are shown and compared. C.D.

A87-34900
UPDATE ON THE U.S. OCEANIC DISPLAY AND PLANNING SYSTEM
AUSTIN GALLOW (IBM Corp., Federal Systems Div., Bethesda, MD) and LONNIE BOWLIN ICAO Bulletin, vol. 41, Dec. 1986, p. 18, 19.

For control of oceanic traffic that flies outside the coverage of land-based radar, a computer-based air traffic systems called ODAPS (Oceanic Display and Planning System) is being implemented. ODAPS will provide oceanic controllers with tools that are already available to the en-route controllers, including a computer-generated situation display and automated flight strips. In addition, ODAPS will provide a strategic conflict-alert probe that will alert controllers to potential conflicts over the vast oceanic airspace, up to hours before they occur. The system is being deployed in three FAA air route traffic control centers, located on Long Island, NY; Oakland, CA; and Miami, FL. The system will also interact with non-FAA systems. Capabilities offered, flight data processing, communications, and displays are covered. Along with maintaining safety, ODAPS will offer the benefits of increased capacity, productivity, efficiency, and fuel economy. D.H.

A87-35177
DFVLR DEVELOPS INEXPENSIVE INTEGRATED NAVIGATION, COMMUNICATION AND AIRSPACE SURVEILLANCE SYSTEM BASED ON THE DISTANCE MEASURING SYSTEM DME [DFVLR ENTWICKELT KOSTENGUENSTIGES INTEGRIERTES NAVIGATIONSUND LUFTRAUMUEBERWACHUNGSSYSTEM AUF DER BASIS DES ENTFERNUNGSMESSSYSTEMS DME]
A. BECKER (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: DFVLR, Annual Report 1985 . Cologne, West Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luftund Raumfahrt, 1986, p. 24-28. In German.

Distance Measuring Equipment (DME) is an approved means of short-range navigation in international civil aviation. Because, in most applications, it utilizes the inherent capacity of the system only to a relatively small degree, additional functions can be

integrated into the system, i.e., data links, ground-derived slant range measurement equipment, and direction finders (growth potential). Thus, DME can be extended to an integrated navigation, communication and surveillance system. For technical, economical and operational reasons, such a system may be superior to conventional solutions that use separate systems for the different functions. Integrated systems can be composed in different ways using different sets of the DME growth elements. One promising set based on the Three-Way DME, which is an extension of the standard DME, is described. It is being proposed for applications in conjunction with helicopters operating between land and off-shore oil rigs. The key elements of the system will first be realized in hardware and flight-tested at the DFVLR research center in Braunschweig. Author

N87-20258# Naval Aerospace Medical Research Lab., Pensacola, Fla.
THE RETINAL IMAGE OF THE FRESNEL LENS OPTICAL LANDING SYSTEM Interim Report
LEONARD A. TEMME and WILLIAM A. MONACO 19 Sep. 1986 37 p
(AD-A176090; NAMRL-1323) Avail: NTIS HC A03/MF A01 CSCL 06P

The theory and geometry by which the Fresnel Lens Optical Landing System (FLOLS) provides glideslope information to the pilot attempting a carrier landing is described. From the theory, geometry, and the linear spatial dimensions of the FLOLS, the image it generates on the retina of the pilot is calculated. Since the dimensions of the retinal image are a function of the distance of the eye from the FLOLS, dimensions are calculated for distances of 1.0, 0.5, 0.25, and 0.125 nautical miles from the carrier ramp and at the ramp itself. These dimensions are also considered as a functions of time in seconds to the ramp, assuming an aircraft airspeed of 125 knots. The dimensions of the retinal image of the FLOLS vary with the FLOLS position on the carrier. Calculations are reported for the USS LEXINGTON (AVT-16) and the USS KITTY HAWK (CV-63). The retinal image of the FLOLS is discussed as a visual stimulus for acuity discriminations and compared to acuity measured in the laboratory. The impact of the addition of the rate descent arrows, AVCARS, on FLOLS visibility is discussed in terms of the calculated dimensions of the retinal image and known neurophysiology. A modification of the current FLOLS display is suggested, which would increase its visibility, gain, and usable range. GRA

N87-20981# Royal Aircraft Establishment, Farnborough (England).
DEVELOPMENTS IN AIR TRAFFIC CONTROL SYSTEMS AND THEIR RELATION WITH METEOROLOGY
T. H. M. HAGENBERG Jan. 1986 22 p Transl. into ENGLISH of "Ontwikkelingen op het Gebied van Luchtverkeersleidingssystemen en de Relatie met Meteorologie" Rept. NLR-MP-84029-U National Aerospace Lab., The Netherlands, Mar. 1984 Original language document was announced as N85-27848
(RAE-TRANS-2143; BR101808; NLR-MP-84029-U) Avail: NTIS HC A02/MF A01

Avionic systems such as secondary surveillance radar and microwave landing systems potential for further automation in air traffic control systems are discussed. The organization of air traffic services and the relation of these services with meteorology are outlined. Author

N87-20982*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ROTARY-WING AIRCRAFT TERRAIN-FOLLOWING/TERRAIN-AVOIDANCE SYSTEM DEVELOPMENT
DAN W. DORR Jun. 1986 11 p Previously announced in IAA as A86-47456
(NASA-TM-88323; A-86283; NAS 1.15:88323) Avail: NTIS HC A02/MF A01 CSCL 17G

Work being accomplished to develop a real-time, piloted simulation of a helicopter using the vertical motion simulator at NASA Ames is discussed. The trajectory generation algorithm and the flight path controller are described, and the software integration of the entire terrain following/terrain avoidance (TF/TA) system is discussed. Real-time simulation requirements and the unique features of applying TF/TA system to helicopter flight are summarized. Initial results indicate that the system is satisfactory for automatic, low level TF/TA helicopter flight. Author

N87-20986# Royal Netherlands Meteorological Inst., De Bilt. Afdeling Fysische Meteorologie.
RUNWAY VISUAL RANGE (RVR) DOCUMENTATION OF THE CIVIL AIRPORTS IN THE NETHERLANDS [RVR-DOCUMENTIE VAN DE CIVIELE LUCHTHAVENS IN NEDERLAND]
A. H. C. STALENHOEF 1986 43 p In DUTCH
(KNMI-TR-84; B8668453; ISSN-0169-1708; ETN-87-99267) Avail: NTIS HC A03/MF A01

The way in which a runway visual range (RVR) table is established using transmissometer data (basic equations, visual thresholds for the perception of light sources, effective intensity of runway lights, composition of an RVR-table) is explained. The choice of the base length for the short base of the transmissometer and the transmissometer position are discussed. The RVR-tables used for civil airports equipped with transmissometers are presented. ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-32070
FLIGHT CONTROL ACTUATORS FOR TOMORROW'S FIGHTERS
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 7, Feb. 1987, p. 24-29.

Design constraints and performance levels of hydraulic actuators for future tactical aircraft flight control systems are examined. The actuators will function at 8000 psi, use nonflammable fluid, and must fit inside extremely thin wings that also carry equipment for, e.g., gust alleviation, load control, etc. Rotary hydraulic actuators are best-suited for thin wings. A direct-drive valve which uses the force output of the engine is a configuration preferred because of its simplicity, and thereby its (supposed) inherent reliability. Using microprocessor-controlled subsystems will enhance overall operations. The nonflammability requirement can be satisfied with CTFE fluid, provided that all valve slots areas are increased to adjust for the higher fluid density of CTFE. M.S.K.

A87-32073
FINITE ELEMENT APPROACH TO ROTOR BLADE MODELING
OLIVIER A. BAUCHAU and CHANG-HEE HONG (Rensselaer Polytechnic Institute, Troy, NY) (Technical Workshop on Dynamics and Aeroelastic Stability Modelling of Rotor Systems, Georgia Institute of Technology, Atlanta, GA, Dec. 1985) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Jan. 1987, p. 60-67. refs
(Contract DAAG29-82-K-0093)

The static and dynamic behavior of helicopter blades is investigated using a finite element approach. This paper focuses on the development of an accurate geometric and structural model of the blade as a first step toward the complete analysis of the aeroelastic problem. A three-dimensional isoparametric beam element including shear and warping deformations of a thin-walled beam made of anisotropic material is formulated for arbitrarily large deflections and rotations. Rotating and non-rotating frequencies for small amplitude vibrations are also presented. The predictions of this model are found in good agreement with experimentally measured deflections and vibration frequencies. Specific advantages of this finite element solution procedure are as follows: the formal derivation of the complex nonlinear equations of motion of the problem is not required, all the nonlinear terms are dealt with in a rational fashion bypassing the need for an ordering scheme, the complex structural behavior of the blade is accurately modeled, and finally both the undeformed and deformed geometry of the blade as well as other specific details of the rotor configuration are taken into account in a natural fashion. Author

A87-32074* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ROTOR-BODY COUPLING REVISITED
WENDELL B. STEPHENS (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and DAVID A. PETERS (Georgia Institute of Technology, Atlanta) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Jan. 1987, p. 68-72. refs

Two analytical procedures are discussed that are currently used to couple rotor and body equations. The first approach, a 'rotor-body iteration' procedure, is often used in flight dynamics simulations. In this approach, acceleration response at the hub interface between the rotor and body are calculated from the body set of equations. These hub acceleration responses are substituted into the rotor set of equations and the remaining rotor acceleration responses are calculated. These rotor responses are used to calculate the rotor hub loads which are transferred back to the body equations to initiate the next iteration. The second method is a 'fully coupled' equations approach that is used in finite element-based analyses. The body and rotor sets of equations are coupled using a kinematic constraint relation at the hub interface. This paper compares the advantages of the two approaches and shows where convergence problems occur in the rotor-body iteration procedure. Author

A87-32103#
A DESIGN METHOD OF AN AIRCRAFT WITH ACT BY NONLINEAR OPTIMIZATION
EIICHI SAWAKI (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan), MAKOTO KOBAYAKAWA (Kyoto University, Japan), and HIROYUKI IMAI (Setsunan University, Osaka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 29, Nov. 1986, p. 142-162. refs

In this paper, a new design method for an efficient system, which is effectively controlled with less energy by the linear optimal feedback control law, is presented, and applied to the design of an aircraft with ACT. If a system has design parameters under various constraints, the cost function which should be minimized by the optimal control law depends on these parameters. Using the 'Complex method', which is one of direct search methods for constrained nonlinear optimization, the design parameters are so determined as to minimize the cost function within the constrained region. As an example, this method is applied to the design of an aircraft with the GLA system, and the newly designed aircraft is compared with the original one designed by the conventional procedures. The results show that the cost function of the newly designed aircraft is reduced considerably and the effect is exemplified through digital simulations and the power spectral density of controlled variables. Author

A87-32584* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
X-29 FLIGHT TEST PROGRAM INCLUDING WIND TUNNEL AND COMPUTATIONAL SUPPORT
E. G. WAGGONER (NASA, Langley Research Center, Hampton, VA), L. A. JENNETT (NASA, Flight Research Center, Edwards, CA), and B. L. BATES (Vigyan Research Associates, Inc., Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 17 p. refs
(SAE PAPER 861642)

A cooperative effort has been defined between NASA-Ames/Dryden Flight Research Facility and NASA-Langley Research Center in support of the X-29A Advanced Technology Demonstrator. The effort involves three phases: flight testing, wind-tunnel testing in the National Transonic Facility, and computational support of each experimental phase. These efforts are primarily aimed at understanding the complex flow phenomena and component interactions associated with the X-29A. Each phase of the effort is discussed in detail and initial data comparisons are presented. In summary, the synergistics effects of the complementary phases are identified, which will enhance the understanding of the unique aerodynamics of the X-29A. Author

A87-32599
COMMERCIAL SUPERSONIC OPERATIONS - TEN YEARS OF EXPERIENCE WITH CONCORDE
S. J. SWADLING (British Aerospace, PLC, Bristol, England) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p.
(SAE PAPER 861683)

This paper is intended to give a brief overview of Concorde development and in-service operations to date. It identifies the features peculiar to Concorde as a supersonic transport and the various problems and major incidents encountered during development and service flying. Finally it covers in-service experience and identifies the most troublesome items. Author

A87-32661
THE AEROELASTIC INSTABILITY OF AN ELEVATOR BALANCE HORN IN A SHEAR LAYER WAKE FLOW
RALPH TATE (Texas Instruments, Inc., Dallas) and RONALD O. STEARMAN (Texas, University, Austin) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 16 p. refs
(SAE PAPER 861827)

The aeroelastic stability of a flexible elevator aerodynamic balance horn in a shear layer wake flow is investigated. The study was motivated by a pilot report of a 'buzzing' observed on his aircraft's elevator aerodynamic horn balances under normal operating cruise conditions. Based on hot wire mean wake flow measurements, a 'cosine'-type math model and a 'Gaussian error function' math model are developed for the shear layer flow field. The resulting nonlinear dynamical equations of motion are evaluated for stability through the analysis of singular points in the phase plane. A limit cycle oscillation is found to occur under trim conditions where the elevator balance horn unports. Compliance with an existing civil aviation requirement for eliminating aeroelastic divergence on controls with aerodynamic horn overhang is recommended pending further study of the galloping phenomenon for the development of design guidelines. Author

A87-32934

A DISCRETE MODEL OF A DEFORMABLE AEROPLANE WITH MOVING CONTROL SURFACES FOR NATURAL VIBRATIONS ANALYSIS

Z. DZYGADLO, I. NOWOTARSKI, and A. OLEJNIK Journal of Technical Physics (ISSN 0324-8313), vol. 17, no. 1-2, 1986, p. 75-84.

A model is presented for numerical analysis of natural vibration modes of a deformable aircraft. Account is taken of the presence of movable control surfaces, for which equilibrium equations are derived on the basis of a beam model. A stiffness matrix is defined for the elastic support at the mounting nodes of the control surfaces. Coordinate transformation techniques are introduced to extend the matrix calculations over a global system of coordinates for the entire aircraft structure. Techniques are also developed to model coupling between the elastic responses of the control surfaces and their mounts. Finally, attention is given to the effects of stiffness on the control surfaces and the stiffness of the control surfaces on the vibration frequencies and modes of the surfaces and the entire system modeled. M.S.K.

A87-33073

CABIN NOISE LEVELS IN SINGLE ENGINE GENERAL AVIATION AIRCRAFT

STANLEY T. HUGHES and JEFFERSON KOONCE (Massachusetts, University, Amherst) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 1381-1385. refs

Sound level measurements were made on several of the most popular general aviation aircraft produced. Measurements were taken at various flight milestones such as: rup up, taxi, climb, cruise power, and descent. For each of the aircraft a time weighted mission sound level was obtained, using three different mission scenarios, varying only in flight time. For each of the three scenarios, and for all aircraft, the time weighted noise values obtained were at or exceeded the 85 dBA limit recommended by NIOSH. The results of this study indicate that a substantial percentage of general aviation pilots will show some loss of hearing due to the high noise levels present in their cabins. Recommendations are made for protection of occupants of general aviation aircraft. Author

A87-33135

F.100 - FELLOWSHIP RENEWED

HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 131, Jan. 24, 1987, p. 20-26.

The F.100 100-seat twin-turbofan airliner has been developed from the earlier F.28 through the stretching of the fuselage by 18 feet and the incorporation of more advanced electronic flight instrumentation and the more powerful 'Tay' turbofan engine. Triple attitude heading reference systems and dual flight management systems, together with two CRT multifunction displays, are encompassed by the new avionics package. The engine nacelles incorporate clamshell thrust reversers for minimum landing distance. The extensive use of structural composites is noted to have saved 920 lb over the projected weight of conventional construction. Attention is given to the marketing successes achieved by this aircraft to date. O.C.

A87-33245*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CONCEPTS FOR REDUCTION OF BLADE/VORTEX INTERACTION NOISE

JAY C. HARDIN (NASA, Langley Research Center, Hampton, VA) and STANLEY L. LAMKIN (PRC Kentron International, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Feb. 1987, p. 120-125. Previously cited in issue 22, p. 3337, Accession no. A86-45477. refs

A87-33651#

MULTILEVEL/MULTIDISCIPLINARY OPTIMIZATION SCHEME FOR SIZING A TRANSPORT AIRCRAFT WING

GREGORY A. WRENN and AUGUSTINE R. DOVI (PRC Kentron, Inc., Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 856-866. refs
(AIAA PAPER 87-0714)

This paper describes the implementation of a multilevel/multidisciplinary optimization scheme for sizing an aircraft wing structure. The scheme is implemented as a three level system analyzing aircraft mission performance at the top level, the total aircraft structure at the middle level, and individual stiffened wing skin cover panels at the bottom level. The system decomposition is based on the ability to obtain sensitivity derivatives of the optimum objective function of the middle and bottom levels with respect to a set of parameters. The overall objective of the effort reported here is to validate the computer implementation of the three level system and demonstrate its ability to converge to a final design from several different starting points. Author

A87-33724#

AEROELASTIC CHARACTERISTICS OF SWEPT CIRCULATION CONTROL WINGS

DAVID HAAS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MA) and INDERJIT CHOPRA (Maryland, University, College Park) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 717-729. refs
(AIAA PAPER 87-0920)

Circulation control airfoils can develop lift coefficients far in excess of conventional airfoils through the use of tangential blowing and thus have potential applications for V/STOL aircraft. The static aeroelastic effects of circulation control on swept wings are examined using two analytical models: a simple two-degree-of-freedom model with linearized aerodynamics and an elastic beam model coupled with nonlinear two-dimensional airfoil data. The static divergence instability and a circulation control reversal phenomenon are investigated through the use of lift and control effectiveness ratios. Effects of wing sweep angle, elastic axis location, blowing level, and spanwise blowing distribution are presented. Linear, nonlinear incompressible, and nonlinear compressible aerodynamic representations are compared. Significant differences were observed between the linear and nonlinear aerodynamic results. It is shown that spanwise blowing distribution can be used to improve undesirable aeroelastic characteristics. The results indicate that the aeroelastic behavior of circulation control wings can be quite different from that of conventional wings. Author

A87-33725*# Maryland Univ., College Park.

USE OF AN IMPLICIT FORMULATION BASED ON QUASILINEARIZATION FOR THE AEROELASTIC RESPONSE AND STABILITY OF ROTOR BLADES IN FORWARD FLIGHT

R. CELI (Maryland, University, College Park) and P. P. FRIEDMANN (California, University, Los Angeles) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 730-742. refs
(Contract NAG2-226)
(AIAA PAPER 87-0921)

This paper describes a new methodology for the formulation of the aeroelastic stability and response problem for helicopter rotor blades. The mathematical expressions for the aerodynamic loads need not be explicit functions of the blade displacement quantities. This methodology is combined with a finite element model of the blade, and a quasilinearization solution technique. The resulting computer program is used to study the behavior of

blades with noncoincident elastic axis, aerodynamic centers, and centers of mass. Author

A87-33726#
CORRELATION AND ANALYSIS FOR SH-2F 101 ROTOR
FU-SHANG WEI and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 743-752. refs
(AIAA PAPER 87-0922)

An SH-2F helicopter flight test data correlation has been successfully performed using a version of the rotorcraft flight simulation program, C81, modified to analyze the servo flap controlled main rotor. Aerodynamic coefficients derived from the airfoil tables are modified to include the servo flap deflection effects, and the analytical model treats the servo flap as a control system only, not a degree of freedom. Very low 4/rev vertical hub shears and 3/rev hub moments are determined, reflecting the low vibrational characteristics of the SH-2F helicopter. Excellent correlation between analysis and test data is found. R.R.

A87-33748*# Georgia Inst. of Tech., Atlanta.
ANALYSIS OF STRUCTURES WITH ROTATING, FLEXIBLE SUBSTRUCTURES APPLIED TO ROTORCRAFT AEROELASTICITY IN GRASP
DEWEY H. HODGES (Georgia Institute of Technology, Atlanta), A. STEWART HOPKINS, and DONALD L. KUNZ (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 955-965. Research supported by the Georgia Institute of Technology. refs
(AIAA PAPER 87-0952)

Application to the General Rotorcraft Aeromechanical Stability Program (GRASP) of new methodology for structural dynamic analysis, including substructuring, frames of reference, nodes, finite elements, and constraints, is discussed. The structure is decomposed into a hierarchy of substructures, and discrete relative motion between substructures is analyzed exactly. The finite element method is used to treat deformation of continua, and the library of finite elements includes a nonlinear beam element incorporating aeroelastic effects. Analytical bases for the aeroelastic beam element and the screw constraint are considered, and the important role of geometric stiffness in the formulation is shown. R.R.

A87-33749*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF GRASP TO NONLINEAR ANALYSIS OF A CANTILEVER BEAM
HOWARD E. HINNANT (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and DEWEY H. HODGES (Georgia Institute of Technology, Atlanta) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 966-975. Research supported by the Georgia Institute of Technology. refs
(AIAA PAPER 87-0953)

The General Rotorcraft Aeromechanical Stability Program (GRASP) was developed to analyze the steady-state and linearized dynamic behavior of rotorcraft in hovering and axial flight conditions. Because of the nature of problems GRASP was created to solve, the geometrically nonlinear behavior of beams is one area in which the program must perform well in order to be of any value. Numerical results obtained from GRASP are compared to both static and dynamic experimental data obtained for a cantilever beam undergoing large displacements and rotations caused by deformation. The correlation is excellent in all cases. Author

A87-33750#
HINGELESS ROTOR RESPONSE TO RANDOM GUSTS IN FORWARD FLIGHT
ANDREW S. ELLIOTT and INDERJIT CHOPRA (Maryland, University, College Park) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 976-986. refs
(Contract DAAG29-83-K-0002)
(AIAA PAPER 87-0954)

The response of a hingeless rotor helicopter to both deterministic and random gusts at various forward speeds is examined analytically using a state space formulation in the time domain. The statically sufficient characteristics of the nonstationary response are obtained by direct time integration of the first order extended state equations, and the rotor is modeled structurally, using the finite element method, as a rotating elastic beam bending out-of-plane. Time histories of blade deflections and hub velocity for the deterministic problem, and the variances of these quantities for the stochastic problem, are considered. Nonstationarity in the gust field is found to have little effect on the response, while altitude and airspeed may significantly alter the mean square hub and blade motion. R.R.

A87-33759*# Maryland Univ., College Park.
GROUND AND AIR RESONANCE OF BEARINGLESS ROTORS IN HOVER
JINSEOK JANG and INDERJIT CHOPRA (Maryland, University, College Park) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1068-1084. refs
(Contract NAG2-409)
(AIAA PAPER 87-0924)

A finite element formulation is used to investigate ground and air resistence in hover for a bearingless rotor. Aerodynamic forces are studied using quasi-steady strip theory, and unsteady aerodynamic effects are introduced through an inflow dynamics model. Reasonable correlation was found between predicted ground and air resonance results and data obtained from measurements using a 1/8th Froude-scaled dynamic model. Systematic parametric studies of the effects of various design parameters were performed, and lag frequency was found to significantly influence ground resonance stability, whereas pitch-lag coupling, blade sweep and pitch link stiffness had powerful effects on air resonance stability. R.R.

A87-33761*# Maryland Univ., College Park.
DESIGN SENSITIVITY ANALYSIS FOR AN AEROELASTIC OPTIMIZATION OF A HELICOPTER BLADE
JOON LIM and INDERJIT CHOPRA (Maryland, University, College Park) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1093-1102. refs
(Contract NAG1-739; DAAG29-83-K-0002)
(AIAA PAPER 87-0923)

The sensitivity of vibratory hub loads of a four-bladed hingeless rotor with respect to blade design parameters is investigated using a finite element formulation in space and time. Design parameters include nonstructural mass distribution (spanwise and chordwise), chordwise offset of center of gravity from aerodynamic center, blade bending stiffnesses (flap, lag and torsion). Hub loads selected are 4/rev vertical hub shear and 3/rev hub moment in the rotating reference frame. The sensitivity derivatives of vertical hub loads with respect to blade design parameters are compared using two approaches, finite difference scheme and analytical approach using

chain rule differentiation. The analytical derivative approach developed as an integral part of response solution (finite element in time) is a powerful method for an aeroelastic optimization of a helicopter rotor. Author

A87-34506#
EULER CALCULATIONS FOR FLOWFIELD OF A HELICOPTER ROTOR IN HOVER
R. K. AGARWAL and J. E. DEESE (McDonnell Douglas Research Laboratories, Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 231-238. Previously cited in issue 17, p. 2474, Accession no. A86-37849. refs

A87-34512*# PRC Kentron, Inc., Hampton, Va.
STRUCTURAL ANALYSIS OF THE CONTROLLED IMPACT DEMONSTRATION OF A JET TRANSPORT AIRPLANE
EDWIN L. FASANELLA (PRC Kentron, Inc., Hampton, VA), E. WIDMAYER (Boeing Commercial Airplane Co., Seattle, WA), and MARTHA P. ROBINSON (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 324-332) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 274-280. Previously cited in issue 18, p. 2610, Accession no. A86-38836. refs

A87-34516#
APPLICATIONS OF SIMILITUDE IN AIRSHIP DESIGN
C. K. LAVAN and C. K. DRUMMOND (Goodyear Aerospace Corp., Akron, OH) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 287, 288.

Attention is given to two clarifications derived through the implementation of the Buckingham pi theorem in a conceptual airship design study. After obtaining a volume sensitivity parameter which allows a very close description of traditional airship performance characteristics in terms of a single curve, the parameters appropriate for a nondimensionalization of airship drag are discussed. O.C.

A87-34702*# Purdue Univ., West Lafayette, Ind.
AEROELASTIC TAILORING - CREATIVE USES OF UNUSUAL MATERIALS
TERRENCE A. WEISSHAAR (Purdue University, West Lafayette, IN) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987. 19 p. NASA-Navy-supported research. refs
(AIAA PAPER 87-0976)

This paper discusses the fundamental aspects of the use of aeroelastic tailoring to enhance the performance of flexible fixed wing aircraft. Tailoring with advanced composites is seen as part of a natural evolutionary process in the everchanging field of design. Among topics discussed are: static divergence; lift effectiveness; drag reduction; control effectiveness; and, vibration and flutter. In addition, terminology is reviewed, together with descriptive formulas that characterize stiffness coupled structures. Finally, a summary of design features favorable to different facets of aeroelastic tailoring is given to illustrate conflicts and compromises that must be considered. Author

A87-34854
HELICOPTER AEROMECHANICS RESEARCH AT DFVLR - RECENT RESULTS AND OUTLOOK
P. HAMEL, B. GMELIN, J. KALEKTA, H.-J. PAUSDER, and H.-J. LANGER (DFVLR, Braunschweig, West Germany) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 93-108. refs

Under the general objectives (1) to adapt the helicopter flying qualities to the pilots' capabilities, (2) to increase the mission effectiveness, and (3) to reduce technical and economical risks of helicopter producers and operators in view of the integration of advanced technologies and increasing automation, DFVLR Institute for Flight Mechanics is conducting research activities in the field of helicopter aeromechanics. In keeping with these objectives the activities are concentrated on three major areas: (1) wind tunnel simulation using large Mach-scaled rotor and helicopter models in the German-Dutch Wind Tunnel (DNW); (2) development of mathematical helicopter models from flight test data by system identification procedures; (3) handling qualities investigations using in-flight simulation. The paper covers the relevant methodologies and facilities at DFVLR as well as various recent results of the research activities. Author

A87-34857* California Univ., Los Angeles.
RECENT TRENDS IN ROTARY-WING AEROELASTICITY
PERETZ P. FRIEDMANN (California, University, Los Angeles) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 139-170. refs
(Contract NAG2-209; NAG2-226)

The purpose of this paper is to survey the principal developments which have occurred in the field of rotary-wing aeroelasticity during the past five-year period. This period has been one of considerable activity and approximately one hundred papers have been published on this topic. To facilitate this review the field has been divided into a number of areas in which concentrated research activity has taken place. The main areas in which recent research is reviewed are: (1) structural modeling; (2) aerodynamic modeling; (3) aeroelastic problem formulation using automated or computerized methods; (4) aeroelastic analyses in forward flight; (5) coupled rotor/fuselage analyses; (6) active controls and their application to aeroelastic response and stability; (7) application of structural optimization to vibration response; and (8) aeroelastic analysis and testing of special configurations. These areas are reviewed with different levels of detail and some useful observations regarding potentially rewarding areas of future research are made. Author

A87-34858
DYNAMICS OF COMPOSITE ROTOR BLADES IN FORWARD FLIGHT
BRAHMANANDA PANDA and INDERJIT CHOPRA (Maryland, University, College Park) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 187-209. refs
(Contract DAAG29-83-K-0002)

The aeroelastic stability and response of flap bending, lead-lag bending and torsion of composite hingeless rotor blades in forward flight is examined, using a finite element formulation based on Hamilton's principle. The blade is treated as a single-cell laminated shell beam composed of arbitrary lay-up of composite plies. Stiffness coupling terms caused by bending-torsion and extension-torsion couplings are identified. Quasi-steady strip theory is used to obtain aerodynamic forces, and the unsteady aerodynamic effects are introduced approximately through a dynamic wake-induced inflow modeling. The blade is discretized into beam elements, each with fifteen nodal degrees of freedom. The blade finite element response equations are transformed to the modal space in the form of a few normal mode equations. These nonlinear response equations containing periodic terms are solved using a time finite element technique and Floquet theory. The periodic perturbation equations linearized about the nonlinear response position are solved for stability using Floquet transition matrix theory in the fixed reference frame. Results are presented for selected structural configurations, categorized as symmetric or antisymmetric according to the lay-up of laminae on opposite flanges. A systematic study is made using changing fiber orientations and different configurations to identify the importance of stiffness coupling terms on blade stability, bending moments and hub forces. Author

A87-34859
A MODEL OF A CURVED HELICOPTER BLADE IN FORWARD FLIGHT
A. ROSEN (Technion - Israel Institute of Technology, Haifa) and O. RAND Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 211-231. refs

A model of a curved helicopter blade in forward flight is presented. A nonlinear model of a rod undergoing small strains and moderate elastic rotations is used in order to describe the structural contributions. The dynamic contributions are treated in

an accurate manner without adopting usual simplifying assumptions. A detailed nonlinear prescribed wake model is used in order to describe the aerodynamic behavior of the curved blades. Curvature influences on the lifting surfaces and the wake are taken into account. It is shown that curvature has a complicated influence on the aerodynamic and coupled aeroelastic behavior of blades. Different beneficial effects of curved blades are pointed out and discussed. Author

A87-34860
SOME BASIC METHODS OF STRUCTURAL DYNAMICS AND UNSTEADY AERODYNAMICS AND THEIR APPLICATION TO HELICOPTERS
R. DAT (ONERA, Chatillon-sous-Bagneux, France) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 249-262. refs

The complexity of a flow due to the combination of helicopter blade rotation and translation is such as to create considerable difficulty in unsteady aerodynamics calculation techniques. In addition, advanced aerodynamic models cannot be coupled with the structural dynamics equations in a straightforward manner, since the unsteady aerodynamic forces depend on the time history of the blades in motion; this requires that the full, coupled aeromechanical problem be solved iteratively. Attention is given to one such iteration algorithm, which is under development by ONERA. O.C.

A87-34862
UNCERTAINTIES IN DYNAMIC DATA FROM ANALYSIS OR TEST OF ROTORCRAFT
ALEX BERMAN (Kaman Aerospace Corp., Bloomfield, CT) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 309-316. refs

When studying phenomena associated with a particular structure, it is often desirable to determine the effects of other attached structures. This paper discusses some of the issues involved in determining simple dynamic representations of such secondary structures. The particular problem addressed is a fuselage model for use in an analysis of helicopter rotor dynamic phenomena. It is shown that reduction of a detailed mathematical model and the direct measurement of dynamic characteristics both involve significant uncertainties and must be performed with great care and with an understanding of the phenomena. Numerical illustrations are presented and general guidelines are discussed. Author

A87-34863* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CALCULATED PERFORMANCE, STABILITY, AND MANEUVERABILITY OF HIGH SPEED TILTING PROPROTOR AIRCRAFT
WAYNE JOHNSON, BENTON H. LAU, and JEFFREY V. BOWLES (NASA, Ames Research Center, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 317-339. refs

The feasibility of operating tilting proprotor aircraft at high speeds is examined by calculating the performance, stability, and maneuverability of representative configurations. The rotor performance is examined in high speed cruise and in hover. The whirl flutter stability of the coupled wing and rotor motion is calculated in cruise. Maneuverability is examined in terms of the rotor thrust limit during turns in helicopter configuration. Rotor airfoils, rotor hub configuration, wing airfoil, and airframe structural weights representative of demonstrated advanced technology are considered. Key rotor and airframe parameters are optimized for high speed performance and stability. The basic aircraft design parameters are optimized for minimum gross weight. To provide a focus for the calculations, two high speed tiltrotor aircraft are considered: a 46-passenger civil transport and an air-combat/escort fighter, both with design speeds of about 400 knots. It is concluded that such high speed tiltrotor aircraft are quite practical. Author

A87-35005#
THE USE OF ARTIFICIAL-INTELLIGENCE METHODS IN THE CONCEPTUAL DESIGN OF LIGHT, AND AERIAL-APPLICATION AIRCRAFT
R. YOELI (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 23-28. refs

An expert system model program which develops light and aerial-application aircraft configurations is proposed. The program is rule based, written in LISP, and consists of a user's interface and an automatic configuration generator. The functions of the production system components, a knowledge-base composed of production rules, a bufferlike data structure, and interpreter, are discussed. The operation of the program is described. Examples of the use of the program to configure an aerial-application and light aircraft are provided. I.F.

A87-35014#
A MODEL FOR HELICOPTER PERFORMANCE CALCULATIONS
D. MENAKER and A. ROSEN (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 111-129. refs

The derivation of a model for calculating helicopter performance in steady flight (constant linear and angular velocities) is presented. The calculated parameters include: fuselage pitch and bank angles, control positions, flapping angles of the main and tail rotor, and the helicopter power consumption. The model is very efficient and thus is appropriate for parametric studies and use with small computers. In order to be able to deal with most of the flight conditions it also includes ground effects, compressibility influences, and the operation of the tail or main rotor in the vortex ring region. The results of the model show nice agreement with flight test results. Author

N87-20176# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter Div.
DESIGN FOR REPAIRABILITY OF HELICOPTER COMPOSITE BLADES
M. HAHN *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 15 p Oct. 1986
Avail: NTIS HC A11/MF A01

First a careful definition is made of the specific kinds of damages where repairability is aimed for. The criteria of repairability are described using the example of the main rotor blade. Then some repair procedures are detailed, starting with the criteria to be used to decide on repair level, showing components in particular and the aspects of design to repairability. Comparison of early and later design is used to demonstrate how improvement with respect to repairability was achieved. The concluding chapter describes service experience with the main and tail rotor blades, gained e.g., out of more than one mio. flight hours of BO 105-fleet. Author

N87-20210# British Aerospace Aircraft Group, Warton (England). Aerodynamics Dept.
THE INTEGRATION OF COMPUTATIONAL FLUID DYNAMICS INTO THE MILITARY AIRCRAFT DESIGN PROCESS
W. R. MARCHBANK *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 13 p Nov. 1986
Avail: NTIS HC A19/MF A01

The rapid analysis and subsequent iterative refinement of aircraft shape is demonstrated by a number of applications of integrated CFD procedures, aimed at achieving specified supersonic performance. Without any reduction in transonic performance, the following complimentary benefits in the supersonic flight regime were established: (1) 5% reduction in drag through fuselage shaping; (2) 3% reduction in drag by decambering the wing through use of flaps; (3) 6% reduction in drag through a reduction in trim

drag; (4) 15% increase in Thrust minus Drag through optimization of the intake flow field. Thus CFD based Project Procedures, used early in configuration design to refine the 3D lines, were used to increase supersonic turn rate by approximately 20%, for a fixed engine thrust, allowing supersonic design requirements to be met without penalizing transonic performance. Author

N87-20216# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Group.
EULER SOLUTION FOR A COMPLETE FIGHTER AIRCRAFT AT SUB- AND SUPERSONIC SPEED
ALBRECHT EBERLE and KENT MISEGADES (Cray Research, Inc., Mendota Heights, Minn.) *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986
Avail: NTIS HC A19/MF A01

A survey is given on the construction of a novel high resolution Euler code which is applied for airflow calculations past a fighter type aircraft. The principle feature of the flow solver is a Godunov type averaging procedure based on the eigenvalue analysis of the Euler equations by means of which the fluxes are evaluated at the finite volume faces which separate constant sets of flow variables on either side. The procedure is third order accurate and locally monotonicity preserving thus avoiding the drawbacks of global TVD-schemes. The grid generation for complex configurations is performed from solutions of linear biharmonic equations with only one parameter prescribed by the program user. Vector computer performance of the explicit and implicit program versions are considered. Author

N87-20226# Boeing Military Airplane Development, Seattle, Wash.
CALCULATIONS FOR A GENERIC FIGHTER AT SUPERSONIC HIGH-LIFT CONDITIONS
J. C. WAI, G. BLOM, and H. YOSHIHARA *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 8 p Nov. 1986
Avail: NTIS HC A19/MF A01

The parabolized Navier/Stokes method was used to calculate the flow over a generic fighter configuration with a canard and underwing nacelles at supersonic high lift conditions. The calculated pressure distributions agreed closely with experiments, but the pitot pressure profile predictions for the boundary layer were less satisfactory largely due to an inadequate mesh in the viscous sublayer. Author

N87-20259 Civil Aviation Authority, London (England).
HELICOPTER EXTERNAL LOAD OPERATIONS
Jul. 1986 18 p
(CAP-426; ISBN-0-86039-287-2; ETN-87-99496) Avail: Issuing Activity

Advice on various aspects of helicopter external load operations for the benefit of operators, pilots, and persons supervising the securing and detaching of loads is given. Airworthiness; route planning; lifting and dropping site; safety of site personnel; safety of third parties at lifting and dropping sites; hand signals; loading procedures; load oscillation; accidental release/snagged loads; weather and altitude; and electrical static charges are covered. ESA

N87-20260 Maryland Univ., College Park.
AEROELASTIC STABILITY OF BEARINGLESS ROTORS IN FORWARD FLIGHT Ph.D. Thesis
ANDREW LYNNE DULL 1986 113 p
Avail: Univ. Microfilms Order No. DA8628975

Aeroelastic stability characteristics for selected bearingless rotor configurations are calculated and correlated to experimental data. The rotor blade is analyzed by a finite element formulation based on Hamilton's principle. The element model has fifteen degrees of freedom in axial, bending and torsion deflections. Quasi-steady strip theory is used for the aerodynamic calculations while non-circulatory forces and dynamic inflow are included to approximate the unsteady effects. The analysis consists of three stages; trim solution, blade steady response, and stability calculations. The trim solution is calculated for a simple rigid articulated blade for either wind tunnel or propulsive trim as the control input to the response calculations. The periodic response is calculated by a time finite element method after the nonlinear finite element in space equations are transformed to normal mode equations using the first few vacuum rotating modes. Then the stability is calculated from the perturbation equations of motion linearized about the steady response solution. These equations are transformed with the first few coupled rotating modes and solved for stability of Floquet transition matrix theory. The bearingless rotor analysis is correlated to hover lag mode stability data for a simple three-bladed rotor tested in three different pitch link configurations. A second more complicated bearingless configuration which includes precone, blade twist, blade sweep, and a lag shear restraint is then analyzed. Dissert. Abstr.

N87-20261*# National Aeronautics and Space Administration, Washington, D.C.
THE DESIGN OF COMPOSITE STRUCTURES: AIRCRAFT DESIGN
G. HELLARD Apr. 1987 24 p Transl. into ENGLISH of "La Conception des Structures Composites" Rept. SNIAS-861-111-103 SNIAS, Toulouse, France, 13 Feb. 1986 p 1-22 Original language document was announced as N86-28082 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TT-20011; NAS 1.77:20011; SNIAS-861-111-103; GCO/GH/CL-442.026/85) Avail: NTIS HC A02/MF A01 CSCL 01C

The principles of aircraft element design using composite materials are outlined. Glass carbon and Kevlar composites are discussed. Sandwich and monolothic structures are described and application criteria are detailed. Drawings detailing the composite elements of the A-310 to A-330 and ATR-42 aircrafts and the particular design of those elements are presented. Author

N87-20262# Royal Aircraft Establishment, Farnborough (England).
WSUH-1D: REVIEW OF DAMAGE FOLLOWING LIGHTNING STRIKE 30 NOVEMBER 1981
T. A. GOBL Sep. 1986 39 p Transl. into ENGLISH of "WSUH-1D: Schadensuebersicht nach Blitzschlag" Rept. TIR-29/81-BWB-ML German Air Force, Erding, West Germany, 1981
(RAE-TRANS-2103; BR101809; TIR-29/81-BWB-ML) Avail: NTIS HC A03/MF A01

This report describes an investigation into the effects of a lightning strike to a BELL UH-1D helicopter operated by the German Air Force. The investigation was made by the Aircraft System Investigation Section of the Air Force Service Regiment, at Erding. Lightning attachments occurred to one main rotor blade, one tail rotor blade and to one undercarriage skid. It was found that arcing had occurred within the aluminum honeycomb core of the main rotor blade sufficient to initiate fatigue cracks in the trailing-edge extrusion. Arcing had also occurred within bearings and between moving parts of the rotor head mechanism. The damage to the rotor head was revealed during routine maintenance and rectification of leaking hydraulic actuators rather than by post-strike inspection. Some of the internal damage to the rotor blade only became evident when the blade was dismantled and was not detectable by NDT methods. Voltage surges induced into the helicopter electrical system caused failure of certain equipment. Author

N87-20263# Bristol Univ. (England). Dept. of Aeronautical Engineering.
MATERIALS SELECTION AND DESIGN STUDY OF A COMPOSITE MICROLIGHT WING STRUCTURE B.S. Thesis
A. J. MURPHY and D. C. MURRAY Jun. 1985 98 p
(BU-335; ETN-87-99198) Avail: NTIS HC A05/MF A01

A design study of a composite wing to replace the built up wing on the MW5 microlight aircraft is presented. Material tests were performed on a wide range of glass fiber reinforced plastics,

and from these an optimum skin configuration was found using a computerized analysis of mathematical models of both the structure and the loading. Styrofoam was chosen as the core material to resist skin buckling, and the resulting wing affords a weight saving of 27% over the built up wing, while giving a reserve factor of 2.8. A method of wing construction was devised, and schemes for the wing fittings were also drafted. The requirement for experimental verification of the wing design was appreciated, and an investigation into the feasibility of using scale models for part of the test program was assessed. ESA

N87-20988# Royal Aircraft Establishment, Farnborough (England).
AILERON REVERSAL OF SWEPT WINGS WITH CROSSFLEXIBILITIES
LL. T. NIBLETT Feb. 1983 24 p
(RAE-TR-83023; RAE-MAT/STR-36; BR88460; ETN-87-99813)
Avail: NTIS HC A02/MF A01

Calculations were made on uniform wings with stiffness properties concentrated at a spanwise axis and the aileron alternatively placed inboard and outboard. Sweepback and sweepforward were considered. Strip theory aerodynamics were used. The results show that flexural flexibility reduces the aileron reversal speed of a sweptback wing when the aileron is outboard and increases it when the aileron is inboard. It has the opposite effect when the wing is sweptforward. In most practical cases, aileron reversal speeds are increased by negative crossflexibility when the aileron is outboard and by positive crossflexibility when the aileron is inboard. ESA

N87-20989# Royal Aircraft Establishment, Farnborough (England).
WING DIVERGENCE AND STRUCTURAL DISTORTION
LL. T. NIBLETT Jun. 1985 30 p
(RAE-TR-85057; RAE-MAT/STR-131; BR97881; ETN-87-99814)
Avail: NTIS HC A03/MF A01

Static aeroelastic equations are formulated for an aircraft performing idealized pull-out and rolling maneuvers. It is concluded from the solutions of these equations that an unaugmented aircraft flying at speeds near the fixed-root divergence speed of its wing suffers low values of control angle per g and control effectiveness in roll and that the distribution of incidence across the wing varies considerably with speed. ESA

N87-20990*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SUMMARY OF STUDIES TO REDUCE WING-MOUNTED PROPFAN INSTALLATION DRAG ON AN M = 0.8 TRANSPORT
RONALD C. SMITH, ALAN D. LEVIN, and RICHARD D. WOOD May 1987 29 p
(NASA-TP-2678; A-86242; NAS 1.60:2678) Avail: NTIS HC A03/MF A01 CSCL 01C

Powerplant installation losses for an advanced, high-speed, turboprop transport have been investigated in the Ames Research Center Transonic Wind Tunnels as a part of the NASA Advanced Turboprop Program (ATP). Force and pressure tests have been completed at Mach numbers from 0.6 to 0.82 on baseline and modified powered-model configurations to determine the magnitude of the losses and to what extent current design tools could be used to optimize the installed performance of turboprop propulsion systems designed to cruise at M = 0.8. Results of the tests indicate a large reduction in installed drag for the modified configuration. The wing-mounted power plant caused destabilizing pitching moments and a negative shift in the zero-lift pitching moment. Author

N87-20991*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CHALLENGES IN MODELING THE X-29 FLIGHT TEST PERFORMANCE
JOHN W. HICKS, JAN KANIA (Air Force Flight Test Center, Edwards AFB, Calif.), ROBERT PEARCE (Grumman Aerospace Corp., Edwards, Calif.), and GLEN MILLS Jan. 1987 14 p
Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987 Previously announced in IAA as A87-22402
(NASA-TM-88282; H-1395; NAS 1.15:88282; AIAA-87-0081)
Avail: NTIS HC A02/MF A01 CSCL 01C

Presented are methods, instrumentation, and difficulties associated with drag measurement of the X-29A aircraft. The initial performance objective of the X-29A program emphasized drag polar shapes rather than absolute drag levels. Priorities during the flight envelope expansion restricted the evaluation of aircraft performance. Changes in aircraft configuration, uncertainties in angle-of-attack calibration, and limitations in instrumentation complicated the analysis. Limited engine instrumentation with uncertainties in overall in-flight thrust accuracy made it difficult to obtain reliable values of coefficient of parasite drag. The aircraft was incapable of tracking the automatic camber control trim schedule for optimum wing flaperon deflection during typical dynamic performance maneuvers; this has also complicated the drag polar shape modeling. The X-29A was far enough off the schedule that the developed trim drag correction procedure has proven inadequate. However, good drag polar shapes have been developed throughout the flight envelope. Preliminary flight results have compared well with wind tunnel predictions. A more comprehensive analysis must be done to complete performance models. The detailed flight performance program with a calibrated engine will benefit from the experience gained during this preliminary performance phase. Author

N87-20992# Naval Postgraduate School, Monterey, Calif.
HOVER PERFORMANCE OF A REMOTELY PILOTED HELICOPTER M.S. Thesis
RANDOLPH P. COTTEN Dec. 1986 56 p
(AD-A176587) Avail: NTIS HC A04/MF A01 CSCL 01C

This paper discusses the hover performance of a remotely piloted helicopter (RPH) and the suitability of the use of this RPH in the academic environment of the Naval Postgraduate School Aeronautical Engineering Department. The methods are those used in the Helicopter Performance Test Manual of the U.S. Navy Test Pilot School. When testing remotely piloted aircraft for use with the military, there is a necessity to test a product to specifications. These specifications may be similar to those of a full sized aircraft. The test methods used are adequate for the testing of RPH's for specification but the use of this equipment in an academic environment is not safe enough without major modification. The RPH has enough excess lift to carry a small test instrumentation package in forward flight. If the RPH is used only in a laboratory environment for the demonstration of hover performance; the gas engine can be replaced with an electric motor and a plexiglas shield can be used between the students and the RPH to satisfy safety precautions. GRA

N87-20993# Naval Research Lab., Washington, D. C.
HARDWARE DESIGN FOR A FIXED-WING AIRBORNE GRAVITY MEASUREMENT SYSTEM Final Report, Jan. - Jul. 1986
JOHN M. BROZENA, JAMES C. ESKINZES, and J. D. CLAMONS 22 Dec. 1986 39 p
(AD-A176620; NRL-9000) Avail: NTIS HC A03/MF A01 CSCL 08E

This report describes the results of a hardware design study for an airborne gravity measurement system. The system is intended for use aboard a fixed wing aircraft for measurements over oceanic areas including ice caps. Hardware for measurement of total vertical acceleration including gravity, aircraft vertical acceleration, and precise positioning is discussed; and example equipment types are specified. A data acquisition system capable of handling all measurements sources is also specified. Various

aircraft operational requirements and parameters are considered. GRA

N87-20994# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
DEVELOPMENT OF OPTIMIZATION SYSTEM OPTSYS: IMPLEMENTATION OF STATIC AEROELASTIC CONSTRAINTS
DAG WIKLANDER Jun. 1986 14 p
(Contract FMV:FFL-82250-85-076-73-001)
(FFA-TN-1986-40; ETN-87-99444) Avail: NTIS HC A02/MF A01

A system for optimization of aircraft structures, OPTSYS, is presented. The implementation of static aeroelastic constraints is outlined. The calculation of flexibility matrices and derivatives of flexibility matrices with respect to design variables are described. These matrices are used in the aeroelastic analysis. The system is operational on VAX computers and CRAY-1A computers. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-31459#
A CUSTOMER'S PERSPECTIVE OF INTEGRATED CNI AVIONICS
ROBERT L. HARRIS (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 76-84. refs

Aspects of the development of integrated CNI avionics systems are discussed in the context of the Integrated Communication Navigation Identification Avionics (ICNIA) program. The ICNIA customer's major problems with today's CNI avionics are examined, and the customer's views of electronics technology as it bears on avionics are summarized. The relationship between ICNIA and the Air Force Reliability and Maintainability Program is addressed, stressing the reliability and maintainability goals that have been established to guide the development of the Air Force full-function ICNIA system. ICNIA software and fault tolerance and ICNIA technology and logistics support are discussed. C.D.

A87-31460
UNIVERSAL RECEIVER FOR ICNIA
FRANK W. SMEAD (ITT Corp., ITT Avionics Div., Nutley, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 85-89.

The design of a 'universal receiver' module for the ICNIA (Integrated Communication Navigation Identification Avionics) system, which allows one common type of receiver module to be used throughout the ICNIA terminal for all signal types, is discussed. The receiver has a broad programmable tuning range from 2 MHz to 2 GHz, the region where most ICNIA signals are located. It can handle the wide variety of ICNIA waveforms, ranging from narrowband conventional voice to Fast Frequency Hopping and spread-spectrum antijam signals.The receiver has a dynamic range over 110 dB for most of the ICNIA signal spectrum, and high resolution tuning down to 2 Hz. Block diagrams of the universal receivers and important subsystems are presented. C.D.

A87-31465
AN ADVANCED FLIGHT CONTROL AND NAVIGATION SYSTEM IMPLEMENTATION FOR TACTICAL HELICOPTERS
CHARLES T. BYE and JEFFREY T. BAKKEN (Honeywell, Inc., Minneapolis, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 127-133.

Unprecedented demands will be placed on the flight control and navigation equipment of the next generation of Army helicopters to enable single crewmember operability in tactical environments. Trade studies were performed concerning the significant issues associated with developing an optimum system architecture. A resulting architecture is discussed which meets anticipated flight control and navigation requirements, at an acceptable weight, by exploiting techniques of functional and physical integration. The architecture maximizes the sharing of sensor and computational resources in a flight critical environment and employs modular equipment packaging, dual fault-tolerant tetrad Ring-Laser-Gyro inertial measurement units, and triplex self-checking processor pair-based flight critical processing channels. Author

A87-31466
HELICOPTER AVIONICS ARCHITECTURE FOR INTEGRATING FLIGHT CRITICAL FUNCTIONS
STEPHEN S. OSDER (McDonnell Douglas Helicopter Co., Tempe, AZ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 134-141. refs

A new approach to the mechanization of the traditional navigation function can provide the key integration interface between the flight critical aircraft Fly-By-Wire stabilization and control and the remainder of the mission avionics. Redundant, integrated navigation and sensor assemblies provide all of the aircraft position, velocity, acceleration, angular rate, attitude, heading and air data states needed for both the flight control as well as the mission management functions. The architectural concept uses functional partitioning with distributed processing aimed at decoupling software dependencies between the various 'integrated' avionics system elements. Author

A87-31467
MISSION AVIONICS FOR THE SH-60F CV HELO
JOHN A. DOWELL (Teledyne Systems Co., Northridge, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 142-149.

The requirements and mechanization of the mission avionics of the Navy's new antisubmarine warfare helicopter, the SH-60F CV Inner Zone ASW Weapon System (CV HELO), are discussed. The system architecture and subsystems for tactical data and display, navigation, communication, sonar, and armament are described. Block diagrams of these subsystems are presented, and the CPU types, language types, and primary functions are given for the software packages that pertain to the various major processing elements. C.D.

A87-31470
ADVANCED HELMET INTEGRATED DISPLAY SYSTEMS
MARTY GUNTHER (Kaiser Aerospace and Electronics Corp., Kaiser Electronics Div., San Jose, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 167-172.

The Advanced Helmet Integrated Display Systems (AHIDS) developed by Kaiser Electronics are state-of-the-art displays which couple the pilot to the tactical situation and aircraft systems. Four helmet systems are currently in development including stroke, raster, and image intensifier display formats. When required, an accurate helmet tracking system provides the correct positioning of target cues and other flight critical position dependent information. The display systems incorporate a unique design concept in that a fully integrated helmet is molded around the optimum optical scheme. AHIDS demonstrate high optical performance in helmets that are lightweight, maintain a low profile, have a tuned center of gravity, and provide the protection of current operational helmets. Since AHIDS are totally new, the design concept includes a modern aesthetic appearance with aerodynamic qualities that are compatible with canopy loss and high speed ejection. Author

A87-31471
AN AVIONIC CAUTION AND ADVISORY DISPLAY PANEL
L. R. STRATHMAN (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 173-176.

A state-of-the-art, avionic Caution and Advisory Display Panel (CADP) which incorporates liquid crystal display (LCD) technology is presented. Reliability performance significantly greater than heretofore realizable is effectively achieved with 100 percent display and electronic redundancy. To maximize performance and reliability, the unit incorporates the following technical innovations: Night Vision Goggle (ANVIS) compatible amber and green color queuing for ease of distinguishing caution messages from advisory messages, high resolution 14-by-14 matrix pixel-array character font to provide eye-ease message readability, fail passive circuit design from the unit electrical connectors through the displays to preclude false message annunciations, and automatic as well as manually initiated BIT to provide aircrew assurance of proper Caution and Advisory Display Panel operation. Author

A87-31490
FLIGHT DECK AVIONICS FOR THE MD-11
LEONARD G. BEKEMEYER and JAMES H. SHANNON (Douglas Aircraft Co., Long Beach, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 307-312.

The MD-11 is designed to permit two-man operation. The flight engineer's station of its parent aircraft, the DC-10, has been deleted and the functions performed by the flight engineer have been automated. This has been made possible by innovative techniques that enable the automatic control of existing DC-10 systems without extensive redesign of those systems. This feature, plus incorporation of electronic instrument subsystems, a flight management system, and digital flight controls will permit a two-man flight crew to safely and efficiently operate this long-range, widebody jet. Described is the design of the MD-11 flight deck avionics and the rationale that led to the selected configuration. Special attention is made to the automated systems control and to the automatic flight control subsystem which provides full-time pitch stability augmentation in addition to the conventional AP/AT/FD functions. Author

A87-31510
AIRBORNE RADAR SENSOR AND DISPLAY PROCESSING
JOSEPH W. IANNIELLO (Norden Systems Inc., Norwalk, CT) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 469-474.

Airborne radar systems require extensive signal processing capability in order to condition raw sensor data, extract information, and format data for presentation on a display. This paper relates the experience gained in the architectural development and design of signal processors for three multimode airborne radar systems currently in final development stages. Much of the emphasis of current literature deals with the programmable signal processors that typically perform the bulk of this signal processing including such functions as imaging, target detection, and target tracking. This paper also addresses the processing functions that are often allocated to specialized hardware elements because of the high data rates and processing throughput requirements. The system optimization rationale for allocating processing functions to various elements and the architectures and technologies that apply to these elements are presented. Author

A87-31511
AVIONICS FOR THE SMALL REMOTELY PILOTED VEHICLE
A. D. VANDERSTEEN (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 475-482.

The Lockheed developmental remotely piloted vehicle (RPV) is a highly sophisticated miniature airplane which represents the current state of the art in RPVs. The avionics, which include flight controls, inertial attitude reference, recovery guidance, payload and data link, represent more than 80 percent of the cost of the vehicle. The key cost drivers are the payload and data link which must accommodate long stand-off range and rapid AV jinking for good survivability, day and night operation, high radio jamming conditions, and high-precision laser pointing accuracy. However, there are many RPV applications which are less demanding and can therefore take advantage of substantial cost reductions. This need is being addressed by defining flexible, adaptive, avionics concepts which emphasize the nondevelopmental philosophy. One such system is the Lockheed Adaptive Modular Payload (LAMP). This system promotes use of a standard universal two-axis gimbal platform into which many different forms of imaging sensors can be installed. This concept is aimed at reconnaissance and surveillance. Author

A87-31515
FAULT-TOLERANCE IN DISTRIBUTED DIGITAL FLY-BY-WIRE FLIGHT CONTROL SYSTEMS
DAVID P. GLUCH and MICHAEL J. PAUL (Allied-Signal, Inc., Bendix Avionics Div., Fort Lauderdale, FL) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 507-514. refs

This paper discusses the critical issues relating to fault tolerance in distributed digital flight control systems for commercial transport aircraft and presents a distributed, air transport digital flight control system design. The key features of the design are assessed in the context of overall mission safety and fault tolerant operation. Techniques used in the design to achieve ultra-high reliabilities to random hardware failures and methods to protect against generic software and hardware faults are presented. The flight control system is based upon the Bendix Multicomputer Architecture for Fault Tolerance (MAFT) Primary Flight Computer design and semi-autonomous 'smart' Actuator Control Electronics (ACE) units. Author

A87-31529
EMBEDDED EXPERT SYSTEMS FOR AVIONICS APPLICATIONS
DAVID BROWN and JOHN M. CARSON (TRW, Inc., Military Electronics and Avionics Div., San Diego, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 608-612.

An expert system designed to support a standard avionics microprocessor is described. The avionics microprocesor memory and speed capabilities which constrain the design and implementation of the expert system are discussed. The expert system contains on-line and off-line functions and its rule structure is based on propositional calculus (if-then logic). The use of fuzzy truths as the uncertainty measures that allow the expert system to operate in real time is examined. The search method employed by the system's inference engine is considered. An example in which the proposed expert system is utilized to control a radar warning receiver is presented to demonstrate the applicability of the design. A diagram of the proposed expert system is provided. I.F.

A87-31530
EMBEDDED EXPERT SYSTEMS FOR FAULT DETECTION AND ISOLATION
CAROLYN SMITH and HORACE SKLAR (TRW, Inc., Military Electronics and Avionics Div., San Diego, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 613-617.

The use of a rule-based expert system embedded in an avionics microprocessor to provide improved real-time fault diagnosis capabilities is examined. The development of the expert system, which employs propositional calculus and data-driven inferencing, is described. A test-bed system consisting of an expert system integrated with the Maintenance and Diagnostic System (MADS) was developed; the components of the MADS and their functions are discussed. The test-bed system was utilized for fault isolation on a board; it is determined that the MADS combined with the expert system improves the speed and accuracy of the fault isolation. I.F.

A87-31546
MODULAR ICNIA PACKAGING TECHNOLOGY
FRANK PORADISH (Texas Instruments, Inc., Avionics Systems Div., McKinney) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 753-756.

Significant size, weight, power, and reliability improvements can be achieved in next generation avionics by the modular integration of similar functions into a fault tolerant reconfigurable architecture. The Integrated Communication Navigation Identification Avionics program (ICNIA) is accomplishing this task with a combination of modular circuit designs using VHSIC technology, improved packaging designs incorporating surface mount component technology, and a modular two-level maintenance support concept for reduced life cycle cost. This article concentrates on the modular packaging technology of the digital processor subsystem. Author

A87-31547
ROTORCRAFT AVIONICS TAILORED FOR ADVERSE CONDITIONS
ASAGAR E. KAPASI (Bell Helicopter Textron, Fort Worth, TX) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 757-764.

An avionics system for helicopter operations under adverse conditions is described. The requirements for the avionics system during zero visibility missions are examined; a diagram of the avionics architecture is presented. The computational flow of the avionics system is discussed. The system processor interfaces with the subsystems and is utilized for communication management, navigation management, continuous monitoring of data for weather and collision avoidance, the processing of built-in-test data, redundancy management and resource management, and video and symbology control. Consideration is given to the FLIR sensor, attitude and heading reference system, ring laser gyro/inertial navigation system, GPS, CO2-laser weather radar, millimeter radar, digital map, control display systems, and sensor fusion. I.F.

A87-31549
THE CONSEQUENCES OF ACCURATE BEARING RESOLUTION ON THE TCAS LIMITED IMPLEMENTATION PROGRAM
BRENDAN SPRATT (Allied-Signal, Inc., Bendix Avionics Div., Fort Lauderdale, FL) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 793-803. FAA-supported research. refs

The hardware implementation of the Federal Aviation Agency's Limited Implementation Program (LIP), which is designed to evaluate the performance of TCAS II in a normal air traffic environment, is described. Consideration is given to the impact of improved directional antenna performance on satisfying the fundamental TCAS requirements and the desires of the pilot community. It is found that the directional antenna offers significant advantages in system performance over that of the basic omnidirectional Tau based TCAS. Moreover, greater target resolution and other display enhancements resulting from improved bearing measurement promote pilot acceptance of TCAS. T.K.

A87-31613#
STEERING BIT BY BIT
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 25, March 1987, p. 12, 13.

A tape storage-based digital terrain map under development for the Air Force for use by pilots flying at low altitudes is described. The tape stores compressed data which contains only information about altitude changes from point-to-point. A prototype system being tested on-board the AFTI F-16 is allowing evaluations of the type of light sources and shading which will optimize the information transfer to pilots. The maps provide pilots to smooth out terrain-following flights by selecting the flight path, and also furnishes the capability of positioning to within 50-100 m. The data, which require 50 Mbits per map, are arranged in blocks on the tape to minimize the reader head travel time. A notable upgrade being planned for the system is a display that is readable in bright sunlight. M.S.K.

A87-32157
OPTICAL EFFECTS OF AIRCRAFT BOUNDARY LAYER TURBULENCE
EARL W. SMITH (Ball Aerospace Corp., Systems Div ., Boulder, CO) Applied Optics (ISSN 0003-6935), vol. 26, Feb. 1, 1987, p. 529-532. refs

A simple model is presented for the optical distortion experience by an airborne optical telescope. This model evaluates the distortion produced by a layer of turbulent air in front of the telescope. A correlation length for the boundary layer is introduced, and theoretical considerations predict that this correlation length should be proportional to the 6/5th power of the wavelength. Comparisons to experimental observations confirm this prediction thereby indicating that the distortion experienced by an airborne telescope is dominated by turbulent air rather than mechanical vibrations or thermal stress. Author

A87-32484
ON-BOARD SYSTEM FOR THE AUTOMATIC CONTROL OF BALLOON ALTITUDE
Y. OKABE, M. FUJII, Y. KOMA, S. OHTA, H. HIROSAWA (Tokyo, University, Japan) et al. IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1549-1553. refs

A high-precision pressure sensor was used to develop a simple and reliable system for the automatic control of balloon altitude. Tested in September 1984, this system was found to function satisfactorily at sunset with a ballast release of 7 percent of the balloon's gross weight. It is concluded that the present system functions as efficiently as ballasting by telecommand at sunset. K.K.

A87-32485
A SIMULATION PLATFORM FOR THREE-AXIS ATTITUDE CONTROL OF A LARGE BALLOON GONDOLA
NOBUYUKI YAJIMA, HARUHISA KUROKAWA, and TOKIO KITAHARA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1555-1560.

A87-32615
INTEGRATED FLIGHT/PROPULSION CONTROL FOR NEXT GENERATION MILITARY AIRCRAFT
LESTER L. SMALL (USAF, Wright-Patterson AFB, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 15 p. refs
(SAE PAPER 861726)

The integration of flight and propulsion control systems on future military aircraft offers the potential for improved steady state and dynamic performance while tolerating faults generated by component failures and battle damage. Achieving this capability will require improved modeling, advances in control and fault-accommodation logic, and redundant computer system architectures with appropriate communication capabilities. Integration of associated systems, such as hydraulic and electrical power, fuel distribution and thermal management, and environmental control, will also be required. Finally, a new management perspective will be needed in both industry and government sectors to foster and mature these 'technologies of integration'. Author

A87-32659
TESTING AND INSTRUMENTATION USED IN THE AN/APG-67 MULTIMODE RADAR
ROGER J. SCHAFER SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p. refs
(SAE PAPER 861823)

Design features and testing techniques applied to the AN/APG-67 multimode radar for the F-20 are described. The system provided range-while-search and velocity search in look up and look down modes, track-on-single target, track-while-scan for multiple targets, automatic acquisition and track for air combat, and aiming for missile guidance. The AN/APG-67 can also map the ground and track ground targets. The operational model has built-in self-test routines. Hardware characteristics are delineated, noting the use of five Z8000 computers to achieve the desired performance levels. Tests were performed on a fully-instrumented C-54 testbed, simulating the operational parameters of an F-20 for comparisons with actual flight data from the aircraft. An interface with a VAX mainframe was employed in the simulations. M.S.K.

A87-32660
THE USE OF SKEWED INERTIAL SENSORS IN FLIGHT CONTROL SYSTEMS
WILLIAM R. SCHLEY (Lockheed-California Co., Burbank, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 11 p.
(SAE PAPER 861825)

The number of gyros and accelerometers required to satisfy flight control system reliability and fault tolerance requirements can be dramatically reduced by abandoning traditional, orthogonal mounting arrangements. This paper describes a simple yet powerful matrix technique for incorporating skewed inertial sensors which includes a method for fault detection, isolation, and reconfiguration. The advantages and practical limitations of the technique, as well as considerations for its physical implementation, are discussed. Signal transformation and redundancy management are illustrated by a numerical example based on a skewed sensor pentad. Author

A87-33041
CADAM APPLICATIONS IN THE DESIGN AND EVALUATION OF AIRCRAFT DISPLAYS
STEPHEN RAUCH (Grumman Aerospace Corp., Bethpage, NY) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1986, p. 699-701.

The rationale for using multicolor CADAM (Computer aided design and manufacturing) in the design and evaluation of the F-14D weapon status panel, head-up, and multifunction display systems is discussed. Examples of specific computer generated display formats for use in the F-14D tactical fighter cockpit avionics system are presented. The use of CADAM permits real-time feedback and full-scale viewing. In addition, with CADAM, the display designer can draw a symbol once, store it in memory, and have the capability to place the symbol into another format. K.K.

A87-33872
DESIGNING TO MIL-STD-2165 - TESTABILITY
DAN CROKE, JAN BRAMEYER (National Aircraft Standards Committee, Washington, DC), and JET K. THOM (Harris Corp., Syosset, NY) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 2, Feb. 1987, p. 23-26.

The incorporation of testability requirements into the V-22 avionics hardware is examined. MIL-STD-2165, which consists of program monitoring and control, design and analysis, and test and evaluation tasks, is a uniform approach for testability program planning. Two approaches, bottom-up and top-down, to implementing MIL-STD-2165 are analyzed. Previous avionics hardware testibility requirements are compared with those applied to the V-22 avionics; the differences between the requirements are discussed. The central integrated checkout which provides effective organizational level fault detection/isolation coverage is described. I.F.

A87-34899
ACAS SIGNAL-INTERFERENCE STUDIES CARRIED OUT IN THE USSR
A. I. ZHOGIN (Aviatsionno-Dispetcherskaia Sluzhba, USSR) and K. Y. KOLOMENSKII (Leningradskii Elektrotekhnicheskii Institut, Leningrad, USSR) ICAO Bulletin, vol. 41, Dec. 1986, p. 15-17.

An account is given of studies in the USSR of airborne collision avoidance systems, particularly systems based on secondary surveillance radar (SSR). Collision avoidance systems based on frequency pulse modulation techniques are considered inexpedient at present in the USSR because of their complexity and high cost. SSR-based systems (beacon collision avoidance systems) are asynchronous systems using interrogation-reply, in which signals similar to SSR system signals are used in radio transmissions. SSR transponders are now installed on the great majority of aircraft in domestic and international operations, and the beacon system permits functioning to be coordinated with ground-based air traffic control services, subject to minor equipment modifications, as well as allowing rapid growth in the protection provided to aircraft when collision avoidance systems start coming into service. Surveillance methods compared include (1) the whisper-shout method, (2) the sector-interrogation method, (3) the altitude-selection method, (4) methods 1 and 2 in combination, and (5) methods 1, 2, and 3 in combination. Despite increasing traffic, no loss in SSR quality or reliability will ensue. D.H.

N87-20264*# Kansas Univ. Center for Research, Inc., Lawrence.
DEVELOPMENT OF A TAKEOFF PERFORMANCE MONITORING SYSTEM Ph.D. Thesis. Contractor Report, Jan. 1984 - Jun. 1985
RAGHAVACHARI SRIVATSAN and DAVID R. DOWNING Mar. 1987 208 p
(Contract NCC1-79)
(NASA-CR-178255; NAS 1.26:178255; KU-FRL-629-1) Avail: NTIS HC A10/MF A01 CSCL 01D

Discussed are the development and testing of a real-time takeoff performance monitoring algorithm. The algorithm is made up of two segments: a pretakeoff segment and a real-time segment. One-time imputs of ambient conditions and airplane configuration information are used in the pretakeoff segment to generate scheduled performance data for that takeoff. The real-time segment uses the scheduled performance data generated in the pretakeoff segment, runway length data, and measured parameters to monitor the performance of the airplane throughout the takeoff roll. Airplane and engine performance deficiencies are detected and annunciated. An important feature of this algorithm is the one-time estimation of the runway rolling friction coefficient. The algorithm was tested using a six-degree-of-freedom airplane model in a computer simulation. Results from a series of sensitivity analyses are also included. Author

N87-20265*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATION OF ALTITUDE AND AIRSPEED INFORMATION INTO A PRIMARY FLIGHT DISPLAY VIA MOVING-TAPE FORMATS
TERENCE S. ABBOTT and GEORGE G. STEINMETZ Apr. 1987 29 p
(NASA-TM-89064; L-16221; NAS 1.15:89064) Avail: NTIS HC A03/MF A01 CSCL 01D

A ground-based aircraft simulation study was conducted to determine the effect on pilot performance of replacing the electromechanical altimeter and airspeed indicators with electronically generated representations integrated into the primary flight display via moving-tape (linear moving scale) formats. Several key factors relating to moving-tape formats were examined during the study: tape centering, secondary (trend) information, and tape orientation. The factor of centering refers to whether the tape was centered about the actual airspeed or altitude or about some defined reference value. Tape orientation refers to whether the values represented are arranged in either descending or ascending order. Six pilots participated in this study, with each subject performing 18 runs along a single, known flight profile. Subjective results indicated that the moving-tape formats were generally better than that of the conventional instruments. They also indicated that an actual-centered fixed pointer was preferred to a reference-centered pointer. Performance data for a visual secondary task showed that formats not containing trend information produced better performance; however, no difference was noted in airspeed tracking or altitude tracking performance. Regarding tape orientation, subjective comments indicated that there was lower work load and better performance when the airspeed tape had the high numbers at the top. Author

N87-20266 Department of the Navy, Washington, D. C.
AIRSPEED SENSING PRESSURE VALVE SYSTEM Patent
PETER AYOUB, inventor (to Navy) 5 Aug. 1986 8 p Supersedes N85-18987, AD-D011472 (23 - 10, p 1425)
(AD-D012569; US-PATENT-4,603,823; US-PATENT-APPL-SN-627-307; US-PATENT-CLASS-244-122)
Avail: US Patent and Trademark Office CSCL 13K

The present invention relates generally to a system for deploying a parachute during ejection of an occupant from a disabled aircraft, and more particularly to a fail-safe means of sensing airspeed in such a system. It is a general purpose and object of the present invention to provide a simple, yet effective airspeed sensor, used in a system for deploying a parachute during ejection of an occupant from a disabled aircraft, which stores peak dynamic pressure in order to selectively delay parachute deployment as a function of airspeed and altitude at ejection. GRA

N87-20995# Analytic Sciences Corp., Reading, Mass.
FAULT-TOLERANT SYSTEM ANALYSIS: IMPERFECT SWITCHING AND MAINTENANCE Final Technical Paper
MICHAEL H. VEATCH and ROBERT D. FOLEY Jan. 1987 32 p
(Contract F33615-82-C-0002)
(AD-A176514; AFHRL-TP-86-49) Avail: NTIS HC A03/MF A01 CSCL 09E

Presented are the results of research into two important areas of concern for fault-tolerant avionics systems: testability analysis and innovative repair policies. The algorithms developed have been included in the Mission Reliability Model (MIREM) and verified by comparison with known results from several Integrated Communication, Navigation, and Identification Avionics architectures. The purpose of the testability analysis was to develop techniques for assessing the impact of imperfect switching on the overall reliability of fault-tolerant avionics. A method of quantifying the effects of undetected errors and false alarms has been developed and included in MIREM. Under the next phase of the program, three repair statistics were identified: Mean Time To Repair, Mean Time Between Maintenance Actions, and Inherent Availability. These were used to define four alternative repair policies: immediate repair, deferred repair, scheduled maintenance, and repair at degraded level. Also included in MIREM as model outputs, these four options offer greater flexibility in evaluating and developing avionics designs. GRA

N87-21467# European Space Agency, Paris (France).
DEVELOPMENT AND OPERATION OF A MEASURING DATA ACQUISITION SYSTEM FOR USE IN LIGHT AIRPLANES
PETER HUBER *In its* Proceedings of Meteorological Motor Glider (MEMO) Workshop '84 (ESA-TT-945) p 160-162 Nov. 1986 Transl. into ENGLISH from "Beitrag zum Workshop MEMO (Meteorologischer Motorsegler)" DFVLR, Oberpfaffenhofen, West Germany, report DFVLR-Mitt-85-04, Jan. 1985 p 157-160 Original language document was announced as N85-35556
Avail: NTIS HC A10/MF A01; original German version available from DFVLR, Cologne, West Germany DM 53

A data acquisition system weighing 35 kg is developed for use onboard light aircraft. The basic concept of the system (task definition, requirements) is given. Development status (onboard components, special systems, ground components, measuring data recorder, technical data, and data evaluation software) is presented. The performed measurements are reviewed. ESA

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AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboa rd auxiliary power plants for aircraft.

A87-31541
IMPROVED ENGINE PERFORMANCE UTILIZING INTEGRATED INLET CONTROL
ERIC D. ALDEN (Allied-Signal, Inc., Bendix Energy Controls Div., South Bend, IN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 710-717. refs

This paper documents the development of a nonlinear multivariable closed loop control for an integrated model of the F100 gas turbine engine with a mixed compression supersonic inlet. The controller is constructed by using a multivariable transfer function synthesis theory called the Total Synthesis Problem (TSP). The implementation of the transfer function synthesis approach to obtain desired output response performance yields both feedforward and feedback controllers in transfer function form. The controllers are easily modified to obtain new desired output response performance. System performance is gauged by the controller's ability to avoid stall conditions and high levels of inlet distortion while providing excellent closed loop response. Author

A87-31723
CALCULATION OF A PLANE NONADJUSTABLE SUPERSONIC AIR INTAKE FOR CAD [RASCHET PLOSKOGO NEREGULIRUEMOGO VOZDUKHOZABORNIKA SO SVERKHZVUKOVOI SKOROST'IU NA VYKHODE DLIA SAPR]
A. D. BOROVIKOV, D. M. DAVIDENKO, V. V. DUGANOV, and A. G. TIKHONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 20-23. In Russian.

A procedure is described for the design and analysis of a plane multistep nonadjustable supersonic air intake. The procedure has been implemented in a software module written in FORTRAN-IV for a computer-aided ramjet design system. The program makes it possible to calculate isolated and ventral air intakes at zero and positive angles of attack. The procedure is illustrated by an example. V.L.

A87-31725
PARAMETERS FOR THE EVALUATION OF COMBINED ENGINE THRUST VECTOR CONTROL SYSTEMS [PARAMETRY DLIA OTSENKI KOMBINIROVANNYKH SISTEM UPRAVLENIIA VEKTOROM TIAGI DVIGATELEI]
B. S. VINOGRADOV, V. I. PANCHENKO, and A. A. TURTANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 28-33. In Russian. refs

A system of parameters and dimensionless factors is proposed for evaluating the efficiency of a combined thrust vector control system including gas injection into the supersonic section of the nozzle and ejection onto the external surface of the flight vehicle. The operation of the gas injection system is evaluated using such parameters as the flow rate of the injected gas, the lateral control force, the drop in axial thrust due to injection, the control moment, and flow rate through the main nozzle. The ejection system is evaluated on the basis of the normal force, the change in drag due to ejection, the control moment associated with ejection, and the flow rate of the ejected gas. V.L.

A87-31726
THEORETICAL DESCRIPTION OF THE COEFFICIENTS OF TURBULENT BOUNDARY LAYER MOTION [TEORETICHESKOE OPISANIE KOEFFITSIENTOV PRISTENNOGO TURBULENTNOGO DVIZHENIIA]
F. G. GALIMZIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 33-38. In Russian. refs

The model structure of turbulent boundary layer motion in aircraft engine components is treated as a system consisting of the following three layers: a viscous sublayer at the wall, a primary turbulence layer due to a three-dimensional wave structure, and a secondary turbulence layer in the main flow. The known and newly obtained coefficients of the turbulent boundary layer motion are described theoretically. Expressions are presented for all the kinematic and dynamic parameters of this kind of motion. V.L.

A87-31728
A UTILIZATION COMPLEX FOR A GAS-TURBINE-ENGINE TEST STATION [UTILIZATSIONNYI KOMPLEKS DLIA ISPYTATEL'NOI STANTSII GTD]
V. I. LOKAI, A. I. ARKHIPOV, IU. A. RZHAVIN, S. V. BOGDANCHIK, and M. A. CHIRKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 43-46. In Russian. refs

A method for utilizing the energy of the exhaust jet during the testing of aviation gas turbine engines is proposed whereby the exhaust jet is used to drive a gas turbine plant. A design of such a turbine is proposed. It is shown that a gas turbine installed next to the exhaust nozzle of the engine being tested makes it possible to utilize the jet energy with an efficiency of at least 40 percent. V.L.

A87-31733
CALCULATION OF JET FLOW IN A DIFFUSER [RASCHET TECHENIIA STRUI V DIFFUZORE]
A. M. TURILOV and G. M. SHALAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 63-67. In Russian.

The interaction between the gas flows of the core and bypass exhausts in the diffuser of a bypass turbofan engine with a common afterburner has a significant effect on the principal engine performance characteristics. Here, a closed system of equations for calculating layered jet flow in a diffuser duct is derived and solved using the Runge-Kutta method. The method has been implemented in computer software written in FORTRAN IV; the results obtained are found to be in good agreement with experimental data. V.L.

A87-31737
ESTIMATION OF THE STAGNATION LINE OF A SYSTEM OF JETS IMPINGING ON A PLANE OBSTACLE IN INCOMING FLOW [K OTSENKE LINII TORMOZHENIIA SISTEMY STRUI, NATEKAIUSHCHIKH NA PLOSKUIU PREGRADU V NABEGAIUSHCHEM POTOKE]
M. M. VYSOKOGORETS, M. SH. GILIAZOV, and N. IU. GOLOVKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 79-81. In Russian.

It has been determined experimentally that the probability of the exhaust gases of the reverse jet entering the air intake of the engine during the post-landing run depends on the position of the stagnation line formed as a result of the interaction of the jet with a screen and incoming flow. If the stagnation line is located in front of the air intake, the exhaust gases enter the intake; if the stagnation line is located behind the inlet section of the intake, the exhaust gases cannot enter the intake. A method for estimating the position and configuration of the stagnation line is presented, and the air flow rate required for a protection jet is calculated. V.L.

A87-31745
CLASSIFICATION OF MATHEMATICAL MODELS OF GAS TURBINE ENGINES. I [KLASSIFIKATSIIA MATEMATICHESKIKH MODELEI GTD. I]
A. P. TUNAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 99-101. In Russian. refs

Some recent mathematical models of gas turbine engines include modules of various degrees of complexity for describing the same turbine units. The appropriate module is then selected in accordance with the required accuracy of calculation and the availability of input data. Here, a classification of gas-turbine-engine models is proposed whereby all the existing modules and modules that may be developed in the future are divided into seven levels of complexity. A formula is also proposed for calculating the complexity of a model as a whole. V.L.

A87-31746
CLASSIFICATION OF CRITERIA FOR THE GASDYNAMIC STABILITY OF A GAS TURBINE ENGINE BASED ON A SET OF ITS PARAMETERS [KLASSIFIKATSIIA KRITERIEV GAZODINAMICHESKOI USTOICHIVOSTI GAZOTURBINNOGO DVIGATELIA PO KOMPLEKSU EGO PARAMETROV]
M. M. SHAKIRIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 101-105. In Russian. refs

Criteria for the gasdynamic stability of gas turbine engines based on a set of engine parameters are classified into four groups depending on their complexity. It is then shown how these criteria can be used to develop methods and devices for the surge protection of gas turbine engines of various types. Such devices are more effective than the existing protection devices due to an increased number of the controlled engine parameters. V.L.

A87-32003
2000 IS (NEARLY) NOW
CLIFTON BERRY, JR. Air Force Magazine (ISSN 0730-6784), vol. 70, Feb. 1987, p. 52-58, 63.

An account is given of the development of technology demonstration and state-of-the-art high performance engines, primarily concerned with military aircraft programs, which are held to indicate the character of airbreathing aircraft propulsion systems for the year 2000 and beyond. Attention is given to the development competition being conducted for the powerplant of the USAF's Advanced Tactical Fighter, which must be capable of sustained Mach 1.8 cruise without compromise of fuel efficiency/range capabilities. Exceptional supportability in the field and low life cycle costs are also stipulated as critical requirements. An engine thrust/weight ratio of 15-20:1, by comparison with the state-of-the art F-100-PW-220 engine's 7.5:1, is expected to be available by the year 2000 as a result of the High Performance Turbine Engine Technology initiative. O.C.

A87-32068
OPTIMIZING AIRCRAFT FUEL THERMAL MANAGEMENT
Aerospace Engineering (ISSN 0736-2536), vol. 7, Feb. 1987, p. 11-13.

Design features of a proposed integrated control system for combining airframe and engine fuel heat sink systems for tactical aircraft are discussed. The widely-used engineering practice of exploiting the fuel as a heat sink also requires holding JP-4 and JP-5 fuel temperatures to below 325 F, preventing boil-off, and ensuring pump inlet pressure to avoid cavitation. Ram air cooling is losing favor because the large inlets are a potential barrier to economical supersonic cruise flight. An integrated system would allow the engine to approach the fuel coking limits during normal flight. The hotter fuel flowing to the engine would serve as a heat sink for the airframe, avionics and other conmponents. M.S.K.

A87-32607* General Electric Co., Fairfield, Conn.
A MODEL PROPULSION SIMULATOR FOR EVALUATING COUNTER ROTATING BLADE CHARACTERISTICS
B. R. DELANEY, C. BALAN, H. WEST (General Electric Co., Fairfield, CT), F. M. HUMENIK (NASA, Lewis Research Center, Cleveland, OH), and G. CRAIG (Boeing Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p.
(SAE PAPER 861715)

Three Model Propulsion Simulators (MPS) were designed and built to evaluate candidate counterrotation Ultra bypass fan model blade designs of nominally 2-ft (0.61 m) tip diameter for an advanced 'pusher-type' aircraft engine. These propulsion simulators (nominally 1/5 engine size) are capable of operation over a wide range of subsonic conditions and can deliver up to 750 shaft horsepower per rotor at rotor speeds of 10,000 rpm. The rotor thrust and torque, dynamic blade stresses, and system temperature data are transmitted through an integral telemetry system to facilitate data acquisition. Salient features of the design, instrumentation, and operation of these simulators are described in this paper. Author

A87-32608
ASPECTS OF TESTING WITH A COUNTER-ROTATING ULTRA BYPASS ENGINE SIMULATOR
EUGENE G. SEVIGNY (Boeing Co., Renton, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 11 p.
(SAE PAPER 861717)

In order to investigate the powered characteristics of new technology transports powered by counterrotating ultra bypass engines, a propulsion simulator for wind tunnel installation testing is required. The design requirements, development, initial testing, and planned application of this propulsion simulator will be discussed. Applications will include powered aspects of stability and control, and aerodynamic considerations of propulsion integration. Author

A87-32611
ULTRA HIGH BYPASS ENGINE APPLICATIONS TO COMMERCIAL AND MILITARY AIRCRAFT
M. A. PAGE, D. M. IVEY, and H. R. WELGE (Douglas Aircraft Co., Long Beach, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 14 p. refs
(SAE PAPER 861720)

A general discussion covering the basic considerations regarding ultra high bypass (UHB) or turboprop propulsion systems and their installation is given. This is followed by a description of the analytical methods used to analyze isolated propellers and complete installed aircraft configurations. Experience with these methods and verification with ground test data have developed confidence in their use. Future verification of the concepts and methods will occur during a Douglas MD-80 demonstrator flight test program to be conducted in 1987. The design experience and verified analytical methods have been used to conduct a number of detailed commercial and military design studies. The results of these are presented indicating significant gross weight and fuel-burn advantages for UHB-powered aircraft concepts. Author

A87-32616
DESIGN VERIFICATION AND ENGINE TEST OF AN ADVANCED FUEL MANAGEMENT SYSTEM FOR AIRCRAFT GAS TURBINE ENGINES
H. J. COOPER, C. F. WEISS (Pratt and Whitney, West Palm Beach, FL), and R. W. VIZZINI (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p.
(SAE PAPER 861727)

This paper describes work conducted under the Navy-sponsored Advanced Fuel Management program. This program undertook the design, development and test of a gas turbine engine control system suitable for installation on the next generation military fighter aircraft. Major features of this control system are a fully redundant system structure; dual electronic controls eliminating all hydromechanical logic elements; redundant direct drive servovalves operating on clean, high pressure, airframe integrated hydraulics supplying all actuation muscle; and redundant high reliability centrifugal fuel pumps. The program, begun in December 1981, was brought to a successful conclusion with the test of the complete control system on a Joint Technology Demonstrator Engine. Author

A87-32618
APPLICATION OF A PANEL METHOD (QUADPAN) TO THE PREDICTION OF PROPELLER BLADE LOADS
R. E. DONHAM, J. D. DUPCAK, and F. CONNER (Lockheed-California Co., Burbank) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p. refs
(SAE PAPER 861743)

A study was conducted to demonstrate the ability of a low order panel aerodynamic flow code to predict the aircraft-induced propeller plane flow field and the resulting steady state propeller blade loads for a single-rotation, wing-mounted tractor system. Comparisons between predicted and measured flow field surveys and resulting blade loads, including the first five harmonics, were made for the U.S. Navy P-3C land-based patrol turboprop aircraft. The study showed that low order flow codes accurately model the induced flow field. Author

A87-32647
FADEC - EVERY JET ENGINE SHOULD HAVE ONE
RICHARD J. SCOLES (General Electric Co., Dayton, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p.
(SAE PAPER 861802)

The design drivers and features of a Full Authority Digital Electronic Control (FADEC) for jet engine fuel supply control are explored. Steady increases in the hardware and operational complexity with the growth in size of jets since the 1950s are reviewed. Increased complexity is necessary to optimize the performance of engines in different climates, altitudes and flight phases. Systems such as FADEC were devised to control the engine fuel requirements and the engine variable geometry, to optimize the engine clearances and reduce the performance-degrading effects of parasitic air, to provide automate and manual starting, optimize engine power management and increase airframe/engine integration. The sensor placements and pilot controls for guiding FADEC operations are described, along with sample procedures implemented by FADEC in optimizing engine fuel supply operations. M.S.K.

A87-32700
WEAR RESISTANCE OF AIRCRAFT FUEL AND HYDRAULIC SYSTEMS [IZNOSOSTOIKOST' AVIATSIONNYKH TOPLIVNO-GIDRAVLICHESKIKH AGREGATOV]
ALEKSANDR FEDOTOVICH AKSENOV and VLADISLAV NIKOLAEVIC LOZOVSKII Moscow, Izdatel'stvo Transport, 1986, 240 p. In Russian. refs

Consideration is given to such topics as failures of fuel and hydraulic systems due to part wear; the wear resistance of moving part joints; the properties of fuels, lubricating oils, and special fluids; the effect of the interaction of fuels, lubricating oils, and structural materials on wear resistance; and methods for assessing and improving the wear resistance of aircraft fuel and hydraulic systems. Specific attention is given to slide-valve pairs of regulatory devices for hydraulic and fuel systems; slide-valve pairs for hydraulic distribution grids; and roller bearings and hinge joints for parts of hydraulic systems. B.J.

A87-33664#
STRUCTURAL DYNAMIC MODELING OF ADVANCED COMPOSITE PROPELLERS BY THE FINITE ELEMENT METHOD
J. B. KOSMATKA and P. P. FRIEDMANN (California, University, Los Angeles) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 111-124. Research supported by TRW, Inc. refs
(AIAA PAPER 87-0740)

An analytical model is presented for determining the free vibration characteristics of conventional and advanced propellers composed of composite materials. The propeller is discretized into a series of straight beam-type finite elements, where the elastic axis of each element is aligned with the line of shear centers of the propeller. Blades of arbitrary shape and definition can be analyzed, since this line of shear centers is represented by a general space curve. The beam-type finite elements are derived, using Hamilton's principle, with allowances for general anisotropic material behavior, cross sections of arbitrary shape, beam pretwist, cross section warping, blade sweep, and nonlinear behavior based on the moderate deflection theory (small strains and finite rotations). The anisotropic material stiffness terms, which couple the bending and torsion displacements with the warping of the cross section, are identified. The natural frequencies and mode shapes are calculated by assuming that the blade motions are small perturbations about the nonlinear static equilibrium position. Numerical results are presented to illustrate the versatility of the method by applying it to conventional and an advanced propeller. Author

A87-35021#
FILM COOLING REQUIREMENTS IN 2-D CONVERGING/DIVERGING VECTORING/REVERSING NOZZLES
B. GAL-OR, A. RASPUTNIS, G. L. CHERULNIC, and H. VARSHAY (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 181-185.

The development of two-dimensional converging/diverging, vectoring/reversing exhaust nozzles is examined. The cooling requirements of the converging/diverging flaps and sidewalls of the nozzle are investigated using two-dimensional model simulations. The model represents a gas turbine engine with an air bleeding from a two-stage centrifugal compressor regulated at 1 kg/sec air flow rate and a nominal nozzle throat area of 19 sq cm. It is observed that at subsonic flow the temperature distribution is two-dimensional and the thrust vectoring generates temperature differences between lower and upper divergent flaps; for supersonic operating conditions the temperature distribution is three-dimensional and the thrust vectoring causes lower temperatures on the convex flow path of the divergent flap. I.F.

A87-35026#
2-D, VECTORING/REVERSING NOZZLES FOR NEW FIGHTER ENGINES - A REVIEW
B. GAL-OR and A. RASPUTNIS (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, *Collection of Papers . Haifa, Technion Israel Institute of* Technology, 1986, p. 225-234. refs

The U.S. Advanced Tactical Fighter is designed to be operative in the mid 90's. It is to be equipped with two-dimensional vectoring/reversing exhaust nozzles. In 1988 the first two-dimensional nozzles will be flight-tested on an F-15 demonstrator fighter. Various laboratory tests have been conducted in recent years to assess the performance of such engine nozzles, especially with respect to STOL and 'Viffing' performance. The new characteristics of such fighters will dramatically change fighter combat. Some of these new engine nozzle characteristics are reviewed, while the performances of various jet-engines are compared. Author

A87-35180
THE PROPFAN LEADS THE WAY TO A NEW GENERATION OF PROPULSION ENGINES [DER PROPFAN LEITET EINE NEUE TRIEBWERKSGENERATION EIN]
P. SCHIMMING (DFVLR, Institut fuer Antriebstechnik, Cologne, West Germany) IN: DFVLR, Annual Report 1985 . Cologne, West Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luftund Raumfahrt, 1986, p. 48-50. In German.

The development status of advanced propfan engines for 120-170-seat short-to-medium-range passenger aircraft to operate at flight Mach numbers 0.7-0.8 is examined, summarizing the results of DFVLR evaluation studies. The need to consider not only fuel economy (for the particular speed and mission) but also the practical installation on the aircraft, engine noise, and reliability and maintainability factors is stressed, and techniques for improving the thermodynamic and/or propulsion efficiency are discussed. The specific fuel consumption of prototype single-rotating-propfan and counterrotating-propfan engines is shown to be about 15 and about 20 percent less, respectively, than that of current turbofan engines. Other types of advanced engine concepts (such as the NASA unducted fan) are briefly characterized. T.K.

N87-20275*# Shenyang Aeroengine Research Inst. (China).
EFFECT OF FLAME-TUBE HEAD STRUCTURE ON COMBUSTION CHAMBER PERFORMANCE
MINQQI GU *In* NASA- Lewis Research Center NASA-Chinese Aeronautical Establishment (CAE) Symposium p 135-147 1986
Avail: NTIS HC A01/MF A01 CSCL 21E

The experimental combustion performance of a premixed, pilot-type flame tube with various head structures is discussed. The test study covers an extensive area: efficiency of the combustion chamber, quality of the outlet temperature field, limit of the fuel-lean blowout, ignition performance at ground starting, and carbon deposition. As a result of these tests, a nozzle was found which fits the premixed pilot flame tube well. The use of this nozzle optimized the performance of the combustion chamber. The tested models had premixed pilot chambers with two types of air-film-cooling structures, six types of venturi-tube structures, and secondary fuel nozzles with two small spray-cone angles. Author

N87-20278*# Gas Turbine Research Inst., Jiangyou (China).
EXPERIMENTAL INVESTIGATION OF PILOTED FLAMEHOLDERS
C. F. GUO, Y. H. ZHANG, and Q. M. XIE *In* NASA- Lewis Research Center NASA-Chinese Aeronautical Establishment (CAE) Symposium p 191-205 1986
Avail: NTIS HC A01/MF A01 CSCL 21E

Four configurations of piloted flameholders were tested. The range of flame stabilization, flame propagation, pressure oscillation during ignition, and pressure drop of the configurations were determined. Some tests showed a very strong effect of inlet flow velocity profile and flameholder geometry on flame stabilization.

These tests led to the following conclusions. (1) The use of a piloted flameholder in the turbofan augmentor may minimize the peak pressure rise during ignition. At the present experimental conditions, delta P/P asterisk over 2 is less than 10 percent; therefore, the use of a piloted flameholder is a good method to realize soft ignition. (2) The geometry of the piloted flameholder and the amount of fuel injected into the flameholder have a strong effect on the pressure oscillation during ignition of the fuel-air mixture in the secondary zone. (3) Compared with the V-gutter flameholder with holes in its wall, the V-gutter flameholder without holes not only has advantages such as simple structure and good rigidity but offers a wide combustion stability limit and a high capability of igniting the fuel-air mixture of the secondary zone.

N87-20280*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONTINGENCY POWER FOR SMALL TURBOSHAFT ENGINES USING WATER INJECTION INTO TURBINE COOLING AIR
THOMAS J. BIESIADNY, GARY A. KLANN, DAVID A. CLARK (Army Aviation Research and Development Command, Cleveland, Ohio.), and BRETT BERGER 1987 14 p Proposed for presentation at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; sponsored by the AIAA, ASEE, ASME and SAE
(NASA-TM-89817; E-3462; NAS 1.15:89817; USAAVSCOM-TR-86-C-32; AIAA-87-1906) Avail: NTIS HC A02/MF A01 CSCL 21E

Because of one engine inoperative requirements, together with hot-gas reingestion and hot day, high altitude takeoff situations, power augmentation for multiengine rotorcraft has always been of critical interest. However, power augmentation using overtemperature at the turbine inlet will shorten turbine life unless a method of limiting thermal and mechanical stresses is found. A possible solution involves allowing the turbine inlet temperature to rise to augment power while injecting water into the turbine cooling air to limit hot-section metal temperatures. An experimental water injection device was installed in an engine and successfully tested. Although concern for unprotected subcomponents in the engine hot section prevented demonstration of the technique's maximum potential, it was still possible to demonstrate increases in power while maintaining nearly constant turbine rotor blade temperature. Author

N87-20281*# National Aeronautics and Space Administration, Washington, D.C.
THEORY AND DESIGN OF FLIGHT-VEHICLE ENGINES
V. T. ZHDANOV, ed. and R. I. KURZINER, ed. Apr. 1987 139 p Transl. into ENGLISH of the book "Teoriya i Konstruktsiya Dvigateley Letatelnykh Apparatov" Academy of Sciences (USSR), Moscow, USSR, 1979 158 p Original language document was announced in IAA as 83A-22651 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88583; NAS 1.15:88583) Avail: NTIS HC A07/MF A01 CSCL 21E

Papers are presented on such topics as the testing of aircraft engines, errors in the experimental determination of the parameters of scramjet engines, the effect of the nonuniformity of supersonic flow with shocks on friction and heat transfer in the channel of a hypersonic ramjet engine, and the selection of the basic parameters of cooled GTE turbines. Consideration is also given to the choice of optimal total wedge angle for the acceleration of aerospace vehicles, the theory of an electromagnetic-resonator engine, the dynamic characteristics of the pumps and turbines of liquid propellant rocket engines in transition regimes, and a hierarchy of mathematical models for spacecraft control engines. IAA

N87-20282*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE AND EFFICIENCY EVALUATION AND HEAT RELEASE STUDY OF AN OUTBOARD MARINE CORPORATION ROTARY COMBUSTION ENGINE
H. L. NGUYEN, H. E. ADDY, T. H. BOND, C. M. LEE, and K. S. CHUN Apr. 1987 24 p Presented at the International Congress and Exposition, Detroit, Mich., 23-27 Feb. 1987; sponsored by the Society of Automotive Engineers
(NASA-TM-89833; E-3488; NAS 1.15:89833) Avail: NTIS HC A02/MF A01 CSCL 21A

A computer simulation which models engine performance of the Direct Injection Stratified Charge (DISC) rotary engines was used to study the effect of variations in engine design and operating parameters on engine performance and efficiency of an experimental Outboard Marine Corporation (OMC) rotary combustion engine. Engine pressure data were used in a heat release analysis to study the effects of heat transfer, leakage, and crevice flows. Predicted engine data were compared with experimental test data over a range of engine speeds and loads. An examination of methods to improve the performance of the rotary engine using advanced heat engine concepts such as faster combustion, reduced leakage, and turbocharging is also presented. Author

N87-20285# Southwest Research Inst., San Antonio, Tex. Fuels and Lubricants Research Div.
THE PHYSICS OF FUEL SPRAYS. VOLUME 1: EXPERIMENTAL MEASUREMENTS Annual Report, Sep. 1985 - Sep. 1986
LEE G. DODGE 5 Dec. 1986 88 p
(Contract N00014-85-C-0841)
(AD-A175660; SWRI-8858/1-VOL-1) Avail: NTIS HC A05/MF A01 CSCL 21D

The objective of this program is to develop a better understanding of gas-turbine-type fuel sprays under realistic high temperature and high pressure evaporating conditions, and also at altitude relight conditions. This includes developing computer models to predict spray behavior and evaporation rates and sophisticated diagnostics to verify these models. Progress includes: (1) Procedures for using the Aerometrics Phase/Doppler instrument and for processing the results have been developed to the point that the instrument can be used to provide benchmark quality data for spray model verification. Specifically, this instrument can be used to provide spatially-resolved drop size distributions, drop velocity distributions, and liquid volume-flux data. Problems in the liquid volume flux measurements close to the atomizer (less than 25 mm) are still being investigated. It was necessary to compare the performance of the Aerometrics Phase/Doppler particle analyzer with the Malvern drop sizing instrument. Because these instruments sample the spray in different ways, techniques were developed to correctly average the overall spray characteristics from measurements of different types of instruments. (2) A new, atmospheric-pressure spray facility was designed and constructed. This facility features a low-turbulence air flow system and computer-controlled nozzle positioning for accurate measurements throughout the spray. (3) The effects of reduced air pressure on atomization were examined. GRA

N87-20286# National Aeronautical Establishment, Ottawa (Ontario).
HIGH TEMPERATURE PROTECTIVE COATINGS FOR AERO ENGINE GAS TURBINE COMPONENTS
P. C. PATNAIK and J.-P. IMMARIGEON Sep. 1986 63 p
(AD-A176001; NAE-AN-42; NRC-26475) Avail: NTIS HC A04/MF A01 CSCL 11C

Aluminide coatings have been widely used in the aircraft industries for the protection of gas turbine engine hot section components against oxidation and/or hot corrosion. This paper considers modes of coating degradation under conditions of cyclic oxidation, hot corrosion and corrosion-erosion interactions during service as well as the effects of interdiffusion between coating and substrate alloys either during service or coating application. It also discusses means of improving existing coatings as well as

advanced coating systems currently under development. In assessing coating performance, consideration must be given to the influence coatings may have on substrate properties such as mechanical strength, resistance to creep and resistance to mechanical and thermal fatigue. Finally it is stressed that proven performance for a given coating/substrate combination is no guarantee that no deleterious reaction will occur, when the same coating is used with a different substrate alloy. Therefore, coating substitution requires requalification. GRA

N87-20997# Allied Bendix Aerospace, Utica, N.Y. Fluid Power Div.
INVESTIGATION AND DESIGN OF A HIGH EFFICIENCY TURBINE WHEEL
L. WILLIAMS Aug. 1986 106 p
(Contract N00019-80-G-00607)
(AD-A176191; REPT-8720-3179U) Avail: NTIS HC A06/MF A01 CSCL 21E

The objective of this task was to design a new turbine wheel to improve the reliability of the 36E144 Air Turbine Starter to be used on the LAMPS SH-60B helicopter. The program concen on strengthening and improving the turbine blade configuration. A stress analysis was conducted to determine the blading characteristics at severe operating conditions. An improved turbine wheel, P/N 2499860 was designed, fabricated, and exposed to a 2000 cycle starter qualification test at NAPC. When inspected after the test, the turbine was in excellent condition and completely free of any defects or distress. The task objective to design and build a more reliable system was achieved. The efficiency level of the new turbine wheel design met Navy requirements. GRA

N87-20998# National Materials Advisory Board, Washington, D.C.
MATERIALS FOR LARGE LAND-BASED GAS TURBINES Final Report, 1984-1986
1986 110 p Sponsored by Electric Power Research Inst.
(PB87-120531; NMAB-430) Avail: NTIS HC A06/MF A01 CSCL 21E

Advanced large land-based gas turbines are expected to be a key component in the generation of electric power based on coal gasification and a combined-cycle gas turbine-steam turbine system. The development of gas turbines in the 120- to 150-MW range with turbine inlet temperatures of 2600 deg F at pressure ratios up to 16.1 is envisioned over the next 15 to 20 years. Currently available and developing materials technology useful for large machines is reviewed and discussed. Although the primary source of these developments is the aircraft engine field, other sources are also reviewed. Suitable technology appears to be available for the development of higher power, long-life turbines for utility power generation. Recommendations are made for specific research and development efforts that address the special requirements and environment of these machines. GRA

N87-21184# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering
VELOCITY AND TEMPERATURE MEASUREMENTS IN A CAN-TYPE GAS-TURBINE COMBUSTOR
A. F. BICEN, M. V. HEITOR (Instituto Superior Tecnico, Lisbon, Portugal), and J. H. WHITELAW *In* AGARD Advanced Instrumentation for Aero Engine Components 12 p Nov. 1986
Avail: NTIS HC A24/MF A01

Velocity and temperature measurements have been obtained in a can-type combustor operating at near atmospheric pressure. Velocity characteristics were determined with a laser Doppler velocimeter and a digitally compensated fine bare-wire thermocouple was used to measure the mean and rms values of temperature fluctuations. The experimental methods are emphasized. The main sources of imprecision are identified, the estimate of the related errors are evaluated. Sample results are given so as to demonstrate the effect of air-fuel ratio on the velocity and temperature characteristics of the combustor. The imprecision in velocity measurements was mainly associated with statistical errors and velocity gradient broadening effects due to the finite size of the measurement volume. The maximum statistical errors were of the order of 2 and 3% for the mean and rms values and the broadening effects can lead to overestimation by up to 25% in the rms values of the swirl velocity component near the swirl center. The error in the mean temperature was mainly due to radiation losses which monotonically increased with temperature and were less than 8%. The catalytic effects were small and limited to regions close to the fuel injector, causing a maximum increase in the mean temperature by no more than 70 K. The uncertainties in the time constant resulted in a maximum error in the rms values of the order of 7%. The effect of AFR on the velocity and temperature characteristics was relatively weak in the primary zone of the combustor. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A87-31540
INTEGRATED CONTROLS - PREPARING FOR THE ADVANCED TACTICAL FIGHTER
RICHARD C. H. PARKINSON (General Electric Co., Aerospace Controls Systems Dept., Binghamton, NY) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 703-709.

Integrated Flight and Propulsion Control (IFPC), in combination with thrust vectoring and multimode variable cycle engines, can yield substantial airplane performance benefits. These benefits are dependent on the airplane configuration and can be maximized only when the airplane is designed as a control configured vehicle. Maximum maneuvering benefits are obtained with a highly unstable airplane. The paper describes the conceptual design of a highly unstable airplane, representative of the Advanced Tactical Fighter, featuring a canard, thrust vectoring, multimode variable cycle engines, and IFPC. Several novel IFPC modes are defined, each maximizing the performance metric of interest to the pilot in one or more mission tasks. These modes optimize either excess specific power or fuel economy for specified normal load factor in all prestall flight conditions. Each IFPC mode is characterized by the use of unique trim deflection schedules for redundant control effectors (canard and vectoring nozzles in the present case) that are functions of flight condition, in conjunction with the use of a specific engine mode. Maneuvering performance benefits of several IFPC modes are given. Author

A87-31731
FIRST ATTAINMENT OF A LEVEL BY A RANDOM PROCESS IN FLIGHT DYNAMICS PROBLEMS [PERVOE DOSTIZHENIE UROVNIA SLUCHAINYM PROTSESSOM V ZADACHAKH DINAMIKI POLETA]
S. L. SEMAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 55-59. In Russian.

A method is proposed for estimating the probability of the first attainment of a specified level by a component of an n-dimensional random process within a specified interval of an independent variable, with specified constraints on the rest of the process variables satisfied at that moment. With the combined distribution density of the components assumed to be known, upper and lower quadrature bounds are obtained of the unknown probability. An example is presented which illustrates the accuracy of probability estimates depending on the nature of the process. The results of the study can be used for evaluating the quality of aircraft control and for control synthesis during landing. V.L.

A87-32072* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE APPLICATION OF QUADRATIC OPTIMAL COOPERATIVE CONTROL SYNTHESIS TO A CH-47 HELICOPTER
BARBARA K. TOWNSEND (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 32, Jan. 1987, p. 33-44. refs

A control-system design method, quadratic optimal cooperative control synthesis (CCS), is applied to the design of a stability and control augmentation system (SCAS). The CCS design method is different from other design methods in that it does not require detailed a priori design criteria, but instead relies on an explicit optimal pilot-model to create desired performance. The design method, which was developed previously for fixed-wing aircraft, is simplified and modified for application to a Boeing CH-47 helicopter. Two SCAS designs are developed using the CCS design methodology. The resulting CCS designs are then compared with designs obtained using classical/frequency-domain methods and linear quadratic regulator (LQR) theory in a piloted fixed-base simulation. Results indicate that the CCS method, with slight modifications, can be used to produce controller designs which compare favorably with the frequency-domain approach. Author

A87-32101#
TRANSONIC AND SUPERSONIC LATERAL CONTROL OF AIRCRAFT BY ADAPTIVE PERFECT SERVO
TATSUO CHUBACHI and AKIRA HASHIMOTO (Iwate University, Morioka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 29, Nov. 1986, p. 121-133. refs

The system stated here is a kind of adaptive tracking servo which implies saturation of internal signals at the transient state. The closed loop transfer function is I2 for this system, and hence the outputs follow the bounded arbitrary inputs without steady errors, if the system constitution is exact. The system is analogous to the so-called pre-differential servo. This system is applied to the transonic and supersonic flight control of the lateral system of F4C fighter aircraft. The simulation showed fairly good results. Author

A87-32118
THE BOEING 7J7 ADVANCED TECHNOLOGY AIRPLANE
PETER L. SUTCLIFFE (Boeing Commercial Airplane Co., Seattle, WA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Feb. 1987, p. 9-15.

Advanced design features being studied for the 7J7 transport aircraft are described, and the impacts the new technologies will have on operational costs are examined. The aircraft, intended to carry 150 passengers, will feature ultrahigh-bypass engines, advanced digital avionics and flat panel displays, composite and Al-Li structural materials, and, possibly, propfan propulsion. A 10 percent reduction in operating cost is expected compared to the A 320 aircraft to be operational in 1989. Some of the savings will be realized by CAD/CAM techniques that define airfoils with natural laminar flow. Primary structures will be Al-Li while secondary structures are projected to be graphite-epoxy thermoset resins. The 7J7 will also carry an on-board maintenance computer for identifying component failures and their replacement procedures, thus reducing maintenance overhead. M.S.K.

A87-32226*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A LOOK AT HANDLING QUALITIES OF CANARD CONFIGURATIONS
SETH B. ANDERSON (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 129-138. Previously cited in issue 21, p. 3045, Accession no. A85-43854. refs

A87-32228#
RECURSIVE ATTITUDE DETERMINATION FROM VECTOR OBSERVATIONS EULER ANGLE ESTIMATION
I. Y. BAR-ITZHACK (Technion - Israel Institute of Technology, Haifa) and M. IDAN (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 628-633) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 152-157. Previously cited in issue 22, p. 3231, Accession no. A85-45943. refs

A87-32233*# Purdue Univ., West Lafayette, Ind.
CLOSED-LOOP PILOT VEHICLE ANALYSIS OF THE APPROACH AND LANDING TASK
DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) and MARK R. ANDERSON (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 30-38) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 187-194. Previously cited in issue 22, p. 3229, Accession no. A85-45880. refs
(Contract NAG4-1)

A87-32234#
DEVELOPMENT AND APPLICATION OF A CONVOLUTION TECHNIQUE FOR FLYING QUALITIES RESEARCH
H. T. BREUL, T. L. KELLER, and R. C. WESTON (Grumman Corporate Research Center, Bethpage, NY) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 195-200. Previously cited in issue 01, p. 12, Accession no. A86-10931.

A87-32646
AIRBUS A320 SIDE STICK AND FLY BY WIRE - AN UPDATE
S. G. CORPS (Airbus Industrie, Blagnac, France) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 15 p.
(SAE PAPER 861801)

This paper discusses the side stick and fly by wire elements of the Airbus Industrie A320. After discussion of the cockpit and the effect on it of the side sticks, the arrangements of the side sticks themselves is discussed, as well as travel, forces and electronic coupling. The control laws form the body of the paper. Pitch, roll and yaw control are discussed in detail as are the protection systems that will contain the flight path within safe limits. Some illustrations of the functioning of the protection system in flight on a test A300 equipped with the A320 control laws are presented. Author

A87-32648* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT TESTING TECS - THE TOTAL ENERGY CONTROL SYSTEM
JAMES R. KELLY, LEE H. PERSON, JR. (NASA, Langley Research Center, Hampton, VA), and KEVIN R. BRUCE (Boeing Commercial Airplane Co., Seattle, WA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p. refs
(SAE PAPER 861803)

This paper describes some of the unique features of an integrated throttle-elevator control law known as the Total Energy Control System (TECS) which has been flight tested on NASA Langley's Transport Systems Research Vehicle. The TECS concept is designed around total energy principles. It utilizes a full-time autothrottle to control the total energy of the aircraft and the elevator to distribute the energy between speed and flight path objectives. Time histories of selected parameters generated from flight data are used to illustrate the pilot-like control strategy of the system and the priority logic employed when throttle limiting is encountered. Author

A87-32649
AIRLINE REQUIREMENTS ON A FLY-BY-WIRE AIRCRAFT - A PILOT'S VIEW
PETER H. HELDT (Deutsche Lufthansa AG, Cologne, West Germany) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 5 p.
(SAE PAPER 861804)

The benefits full fly-by-wire (FBW) control systems, without or with partial mechanical backup, will have for the operation of civil transport aircraft are examined. Digital FBW systems will provide facile access to the full flight envelope, automatic recovery from performance-limited conditions, enhanced handling, reduced training costs, and flexibility in the flight deck configurations. It is recommended that FBW systems have a 1:1 billion failure probability, partially achieved through redundancy, and that avionics displays be simplified and placed in view immediately in front of the pilot. Control stick force responses and control reactions to pilot inputs in various flight situations are delineated. Conditions in which the pilot may need the option of overriding the automatic flight controller, which keeps the aircraft performance within the aerodynamic and structural design envelopes, are discussed.
M.S.K.

A87-33047
DEVELOPMENT AND EVALUATION OF A PROPORTIONAL DISPLACEMENT SIDEARM CONTROLLER FOR HELICOPTERS
R. V. KRUK, D. W. RUNNINGS, M. KING, A. L. LIPPAY, and G. M. MCKINNON (CAE Electronics, Montreal, Canada) IN: Human Factors Society, Annual Meeting, 30th, Dayton, OH, Sept. 29-Oct. 3, 1986, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1986, p. 865-869. refs

Associated with the development of fly-by-wire control systems for use in helicopters has been the prospect of replacing all of the current manual flight controls in the cockpit with a single sidearm controller. For the most part, the technology available for this concept has consisted of variations of force sensing sidearm controllers. The human proprioceptive system, hower, does not perform optimally in force discrimination and stable maintenance of force outputs. One consequence of this is that operator feedback with respect to direction and magnitude of control input with force sensing manual control systems is relatively poor. An alternative approach applying proportional displacement sensing rather than force sensing was developed and evaluated via laboratory studies and flight tests in a research helicopter. The results to date indicate that pilot workload and performance with a displacement sensing controller are equivalent to conventional controls and superior to a force sensing controller across a wide spectrum of flight conditions and maneuvers. All four control functions (i.e., roll, pitch, yaw, and collective) were on one hand in both the force and displacement sensing configurations. A sidearm controller utilizing displacement sensing rather than force sensing retains most of the advantages of the latter (e.g., simplicity, compactness) while offering superior compatibility with human operator sensorimotor characteristics.
Author

A87-33326
ON THE APPLICATION OF AXIOMATIC AERODYNAMIC MODELLING TO AIRCRAFT DYNAMICS
G. J. HANCOCK and J. S. Y. LAM (Queen Mary College, London, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Jan. 1987, p. 1-28. SERC-supported research. refs

Axiomatic aerodynamic modeling attempts to ascertain the validity of aerodynamic modeling efforts with respect to aircraft dynamics, emphasizing the relationship of full scale behavior in flight to wind tunnel test data-based behavior predictions. Attention is presently given to the case of the attached flow behind a wing and a tailplane, on the basis of a vortex lattice representation, with the wing wake fully relaxed at each instant of time. Predicted responses based on the conventional derivatives thus obtained are compared with exact responses, using the axiomatic model for various elevator inputs and for both swept and unswept aircraft configurations. The model is then extended to an aircraft moving in a general coupled longitudinal-lateral motion, but with the flow attached throughout the motion. Results are given for swept wing aircraft responses due to separate rudder and aileron inputs.
O.C.

A87-33661#
SUPERSONIC FLUTTER OF AEROELASTICALLY TAILORED OBLIQUE WINGS
TERRENCE A. WEISSHAAR and JONATHAN M. BOHLMANN (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 55-65. refs
(Contract N62269-85-C-0268)
(AIAA PAPER 87-0734)

Renewed interest in oblique wing aircraft has created curiosity about the possible use of aeroelastic tailoring to enhance its aeroelastic stability. This paper examines the flutter characteristics of an idealized, advanced composite, oblique wing configuration operating at supersonic speeds. The theoretical model consists of a uniform property wing with beam-like flexural and torsional flexibility as well as bend-twist deformation cross-coupling. The wing is free to roll unrestrained about a streamwise roll axis. Quasi-steady, linearized supersonic aerodynamic theory is used to describe the deformation dependent aerodynamic forces. The effects of characteristic inertial, aerodynamic and structural parameters on flutter behavior is surveyed. Among these parameters are: wing aspect ratio; mass ratio; Mach number; fundamental bending-torsion frequency ratio; bend-twist deformation coupling; wing sweep angle; and, the wing-to-fuselage roll mass moment of inertia ratio. It is shown that when tailoring is used to increase the stability of a body-freedom mode, the result is a degradation of other high-frequency modes. This behavior is similar to that observed on conventional wings. The result is that too much stiffness cross-coupling is undesirable as a passive measure to control flutter.
Author

A87-33676#
VALIDATION OF FLUTTER TEST ANALYSIS METHOD
B. A. WINTHER and D. L. COWAN (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 226-232. refs
(AIAA PAPER 87-0780)

In evaluating parameter identification methods, several investigators have emphasized the need for simulated aircraft response data with well defined and known dynamic characteristics. This paper presents the development of a real-time simulation model for a generic stability-augmented aircraft flying in a turbulent atmospheric environment and responding to test excitation provided by the control surfaces. Data generated in the simulation are used to validate a flutter test analysis procedure that is based on Fast Fourier Transform (FFT) techniques. The procedure is made applicable to aircraft both with and without stability augmentation. Based on the results, the following conclusions are drawn: (1) the flutter test analysis method is effective in identifying dynamic characteristics of the aircraft, (2) sensitivity to atmospheric turbulence is reduced significantly by application of an exponential window to the impulse response function, and (3) a realistic simulation model is of great value for validation of the analytical method.
Author

A87-33677#

WIND TUNNEL TEST AND ANALYSIS ON GUST LOAD ALLEVIATION OF A TRANSPORT-TYPE WING

Y. MATSUZAKI (Nagoya University, Japan), T. UEDA, T. MIYAZAWA, and H. MATSUSHITA (National Aerospace Laboratory, Chofu, Japan) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 233-241. refs

(AIAA PAPER 87-0781)

The present paper describes experimental and analytical results of gust response of a 1/9 scale transport-type wing with a gust load alleviation system. A reduced-order feedback control filter is formed with the aid of a modified optimal control theory. The system using the feedback filter has been confirmed to be effective against both sinusoidal gust and atmospheric turbulence. Detailed comparison is made by taking into account the effect of location of the leading-edge and the trailing-edge control surface. Because of the vertical setup of the wing on the floor, gravitational acceleration has a serious effect on the accelerometer's signal , and consequently, on control of the wing response in a low frequency range. In general, agreement between analysis and experiment is good. Author

A87-33695#

MULTI-CONTROL SYSTEM IN UNSTEADY AERODYNAMICS USING SPOILERS

R. DESTUYNDER (ONERA, Chatillon-sous-Bagneux, France) and HEINZ HOENLINGER (Messerschmidt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 421-427.

(AIAA PAPER 87-0855)

A theoretical and experimental study has been developed with the aim of validating the use of spoilers in automatic multicontrol systems. Using a Froude scaled model, representing roughly an existing plane, wind tunnel tests at low speed were performed to validate the theory for different control laws applied simultaneously on the same control surfaces. The second objective was to compare the use of different control surfaces for the same type of control (flutter, gust, stability). Author

A87-33701*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

FLUTTER STUDY OF AN ADVANCED COMPOSITE WING WITH EXTERNAL STORES

STANLEY R. COLE, JOSE A. RIVERA, JR. (NASA, Langley Research Center, Hampton, VA), and K. S. NAGARAJA (Boeing Military Airplane Co., Seattle, WA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 480-490. refs

(AIAA PAPER 87-0880)

A flutter test using a scaled model of an advanced composite wing for a Navy attack aircraft has been conducted in the NASA Langley Research Center Transonic Dynamics Tunnel. The model was a wall-mounted half-span wing with a semi-span of 6.63 ft. The wing had an aspect ratio of 5.31, taper ratio of 0.312, and quarter-chord sweep of 25 degrees. The model was supported in a manner that simulated the load path in the carry-through structure of the aircraft and the symmetric boundary condition at the fuselage centerline. The model was capable of carrying external stores from three pylon locations on the wing. Flutter tests were conducted for the wing with and without external stores. No flutter was encountered for the clean wing at test conditions which simulated the scaled airplane operating envelope. Flutter boundaries were obtained for several external store configurations. The flutter boundaries for the fuel tanks were nearly Mach number independent (occurring at constant dynamic pressure). To study the aerodynamic effect of the fuel tank stores, pencil stores (slender cylindrical rods) which had the same mass and pitch and yaw inertia as the fuel tanks were tested on the model. These pencil store configurations exhibited a transonic dip in the flutter dynamic pressure, indicating that the aerodynamic effect of the actual fuel tanks on flutter was significant. Several flutter analyses methods were used in an attempt to predict the flutter phenomenon exhibited during the wind-tunnel test. The analysis gave satisfactory predictions of flutter for the pencil store configurations, but unsatisfactory correlation for the actual fuel tank configurations. Author

A87-33702*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ACTIVE SUPPRESSION OF AN 'APPARENT SHOCK INDUCED INSTABILITY'

WILLIAM M. ADAMS, JR., SHERWOOD H. TIFFANY, and RICHARD E. BARDUSCH (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 491-505. refs

(AIAA PAPER 87-0881)

A control law was designed, using constrained optimization techniques, to suppress an apparent shock induced instability of a sweptback, aeroelastic wing with supercritical airfoil sections. The controller design was based on an approximate linear plant representation obtained using forced response data from a previous entry in the Langley Transonic Dynamics tunnel. During a second tunnel entry, it was found that there was not an instability in the uncontrolled case but there was a region of very low damping (high dynamic response) near a Mach number of 0.92. Controller performance was obtained during the test in near real-time and revealed that the controller attenuated the open-loop response and provided a small but significant amount of damping over a Mach number range from $M = 0.70$ to $M = 0.92$. Author

A87-33715#

FLUTTER ANALYSIS OF AERONAUTICAL COMPOSITE STRUCTURES BY IMPROVED SUPERSONIC KERNEL FUNCTION METHOD

CHUAN-QI HUANG, JING-SONG CHEN, and SHING CHIAO (Nanjing Aeronautical Institute, People's Republic of China) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 629-635. Research supported by the Chinese Academy of Sciences.

(AIAA PAPER 87-0906)

A flutter analysis of composite aeronautical structures is presented which uses the FEM and the Lancoz method to obtain free vibrational modes. Generalized aerodynamic coefficients are determined by an improved supersonic kernel function method, and an automatic technique is used to evaluate the critical flutter point. The efficiency of the method is demonstrated with two test problems. A finite element calculation of a composite vertical empennage is also performed, and good agreement is found with results obtained by the commonly used subsonic doublet-lattice method. It is found for composite complex structures that the flutter mode is not always the second one. R.R.

A87-33716*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
INTEGRATED AEROSERVOELASTIC ANALYSIS CAPABILITY WITH X-29A ANALYTICAL COMPARISONS
K. K. GUPTA, M. J. BRENNER, and L. S. VOELKER (NASA, Flight Research Center, Edwards, CA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 636-647. refs
(AIAA PAPER 87-0907)

An extension of the program STARS (a general-purpose structural analysis program) has been developed; this extension implements a complete aeroservoelastic analysis capability. Previous capabilities included finite-element modeling as well as statics, buckling, vibration, dynamic response, and flutter analyses. This paper presents a description and the formulation of STARS in its current state along with example dynamic, aeroelastic, and aeroservoelastic analyses pertaining to the X-29A aircraft. These examples include vibration analysis results as well as flutter analysis results obtained by the conventional k method and the velocity root-contour solution. Finally, selected open- and closed-loop aeroservoelastic analysis results based on a hybrid formulation are compared to illustrate, using the calculated frequency responses, the interactions of structures, aerodynamics, and flight controls. Author

A87-33717#
THE APPLICATION OF TRANSIENT AERODYNAMICS TO THE STRUCTURAL NONLINEAR FLUTTER PROBLEM
L. O. BRASE (McDonnell Aircraft Co., Saint Louis, MO) and W. EVERSMAN (Missouri-Rolla, University, Rolla) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 648-656. refs
(AIAA PAPER 87-0908)

A method is presented for the exact solution of the structural nonlinear flutter problem. Excellent agreement between the linear standard reduced frequency and transient flutter solutions is obtained for both a simplified two degree of freedom system with Theodorsen two-dimensional incompressible unsteady aerodynamics and a multiple degree of freedom system with three-dimensional compressible unsteady aerodynamics. The transient solution is then utilized to develop an approach for precisely including the effects of structural nonlinearities. This approach provides the capability of using the same detailed structural and aerodynamic models for both linear and nonlinear analyses. Author

A87-33718#
FLUTTER INVESTIGATIONS INVOLVING A FREE FLOATING AILERON
MARK FRENCH, THOMAS NOLL, DALE COOLEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), ROBERT MOORE, and FAUSTINO ZAPATA (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 657-663.
(AIAA PAPER 87-0909)

The T-46A jet trainer encountered an unexpected flutter oscillation in flight while investigating the effects of a reduction in aileron mass balance. The flutter incident involved the interaction of the free floating aileron rotation mode with the wing bending mode. Pre-test analyses that used modified strip theory aerodynamics did not predict the instability for the conditions tested. This paper presents the results of a post-test analytical effort conducted to determine the effects of control surface aerodynamic efficiency on the flutter mechanism. Both modified strip theory and the doublet lattice lifting surface theory were used to calculate the unsteady aerodynamics required for these flutter analyses. The range of control surface aerodynamic efficiency was determined based on guidance provided from previous analytical and wind tunnel data for other aircraft configurations. These analyses indicated that the reduction of control surface aerodynamics could have a detrimental effect on stability in the control surface rotation mode. Calculated results predicted the flutter phenomenon when the aileron aerodynamic effectiveness was reduced by about 50 to 60 percent. Author

A87-34508*# Vigyan Research Associates, Inc., Hampton, Va.
FOREBODY VORTEX MANAGEMENT FOR YAW CONTROL AT HIGH ANGLES OF ATTACK
DHANVADA M. RAO (Vigyan Research Associates, Inc., Hampton, VA), DANIEL G. MURRI (NASA, Langley Research Center, Hampton, VA), and CARY MOSKOVITZ (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 651-661) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 248-254. NASA-USAF-supported research. Previously cited in issue 24, p. 3548, Accession no. A86-49047. refs

A87-34515*# San Diego State Univ., Calif.
PROPELLER SWIRL EFFECT ON SINGLE-ENGINE GENERAL-AVIATION AIRCRAFT STALL-SPIN TENDENCIES
JOSEPH KATZ (San Diego State University, CA) and TERRY W. FEISTEL (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 285-287. refs

An investigation is conducted of the effect of a single engine, untapered low wing general aviation aircraft propeller's swirl on the craft's stall pattern. The asymmetrical character of the propeller's swirl can trigger an early stall of one of the wings, aggravating the spin-entry condition. It is shown that the combination of this propeller-induced effect with adverse sideslip can result in large and abrupt changes in the rolling moment, in such conditions as uncoordinated low speed turning maneuvers where the pilot yaws the aircraft with wings level, rather than rolling it. O.C.

A87-34704#
THE STUDY OF AIRCRAFT ADAPTIVE CONTROL AUGMENTATION SYSTEM IMPLEMENTED WITH MICROCOMPUTER
WEI WANG and SHUNDA XIAO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Automatica Sinica, vol. 12, Oct. 1986, p. 361-367. In Chinese, with abstract in English. refs

The scheme proposed by Hartmann and Krebs (1980) has been improved in this paper on the gain adaptation laws. A concise, reasonable model under parameter estimation, and an identification algorithm are proposed. Computation workload has been decreased to 50 percent of the original. Thus, the quality of the parameter estimation is satisfactory, and the adaptation laws are more practical. The microcomputer implementation of the scheme is studied. Digital-analog hybrid simulation results show that such a scheme possesses simplicity of algorithm, and it can be easily realized from an engineer's point of view. The software satisfies accuracy, real time and flight control quality requirement. Author

A87-34852
RESPONSE OF A HELICOPTER PENETRATING THE TIP VORTICES OF A LARGE AIRPLANE
AKIRA AZUMA, KEIJI KAWACHI (Tokyo, University, Japan), and SHIGERU SAITO (National Aerospace Laboratory, Chofu, Japan) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 65-76. refs

The dynamic response of helicopters penetrating a pair of trailing vortices of a jumbo jet is analyzed. The rotor aerodynamic forces which are fully coupled with the body motion with six degrees of freedom are calculated by using the local momentum theory (LMT). The wake vortices of the jumbo jet are assumed to be a frozen gust and are disturbed by the blade motion. The time histories of the dynamic behaviors of the helicopter as well as the blade motion are presented for the various parameters such

as the distance between the helicopter and the jumbo jet, the type of helicopter rotor, and the flight path angle with respect to the trailing vortex of the jumbo jet. Author

A87-34853* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INFLUENCE OF DYNAMIC INFLOW ON THE HELICOPTER VERTICAL RESPONSE
ROBERT T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) and WILLIAM S. HINDSON (Stanford University, CA) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 77-91. refs
A study has been conducted to investigate the effects of dynamic inflow on rotor-blade flapping and vertical motion of the helicopter in hover. Linearized versions of two dynamic inflow models, one developed by Carpenter and Fridovich and the other by Pitt and Peters, were incorporated in simplified rotor-body models and were compared for variations in thrust coefficient and the blade Lock number. In addition, a comparison was made between the results of the linear analysis, and the transient and frequency responses measured in flight on the CH-47B variable-stability helicopter. Results indicate that the correlations are good, considering the simplified model used. The linear analysis also shows that dynamic inflow plays a key role in destabilizing the flapping mode. The destabilized flapping mode, along with the inflow mode that the dynamic inflow introduces, results in a large initial overshoot in the vertical acceleration response to an abrupt input in the collective pitch. This overshoot becomes more pronounced as either the thrust coefficient or the blade Lock number is reduced. Compared with Carpenter's inflow model, Pitt's model tends to produce more oscillatory responses because of the less stable flapping mode predicted by it. Author

A87-34855
HELICOPTER INDIVIDUAL-BLADE-CONTROL RESEARCH AT MIT 1977-85
NORMAN D. HAM (MIT, Cambridge, MA) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 109-122. refs
A new, advanced system for active control of helicopters and its application to the solution of rotor aerodynamic and aeroelastic problems is described. Each blade is individually controlled in the rotating frame over a wide range of frequencies. Application of the system to gust alleviation, attitude stabilization, vibration alleviation, blade lag damping augmentation, stall flutter suppression, blade flapping stabilization, stall alleviation, and performance enhancement is outlined. The effectiveness of the system in achieving most of these applications is demonstrated by experimental results from wind tunnel tests of a model helicopter rotor with individual-blade-control. The feasibility of achieving many or all of the applications of individual-blade-control using the conventional helicopter swash plate is demonstrated, and the necessary control laws are presented. Author

A87-34856
DEVELOPMENT OF AN EXPERIMENTAL SYSTEM FOR ACTIVE CONTROL OF VIBRATIONS ON HELICOPTERS - DEVELOPMENT METHODOLOGY FOR AN AIRBORNE SYSTEM
MARC ACHACHE and MICHEL POLYCHRONIADIS (Aerospatiale, Division Helicopteres, Marignane, France) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 123-138. refs
An account is given of the developmental methodology being used to define an experimental system for helicopter main rotor blade higher harmonic vibration control. The stages leading to test flights range from the theoretical modeling of helicopter vibratory behavior under higher harmonic control to the integration of the system on a rotor test rig. This closed loop, self-adaptive system of rotor vibration reduction has been validated for the entire flight envelope of a SA 349 helicopter. Three different algorithms have yielded 80-percent average reductions of cabin noise at 250 km/hr. O.C.

A87-35002#
FLIGHT CONTROL SYNTHESIS VIA EIGENSTRUCTURE ASSIGNMENT - THE DISCRETE VERSION
K. M. SOBEL (Lockheed-California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 1-6. refs
The use of eigenstructure assignment for flight control system design is examined. The eigenstructure assignment provides a noniterative synthesis method which incorporates military specifications on damping, frequency, and decoupling. The modifications that are required for the eigenstructure algorithm to be applied to the designing of fly-by-wire flight control systems are described. Examples of analog flight control and digital fly-by-wire flight control designs are presented. I.F.

A87-35018#
DESIGN OF FAST NON-INTERACTING DIGITAL FLIGHT CONTROL SYSTEMS FOR SHORT-TAKEOFF-AND-LANDING AIRCRAFT
B. PORTER, A. MANGANAS, and T. MANGANAS (Salford, University, England) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 157-164. SERC-supported research. refs (Contract AF-AFOSR-85-0208)
In order to remove all 'slow' modes from plant outputs, discrete-time tracking systems incorporating fast-sampling error-actuated digital PID controllers are introduced. It is shown that the resulting discrete-time tracking systems exhibit set-point tracking characteristics which are both fast and noninteracting of the kind previously achievable only for regular multivariable plants with full-rank first Markov parameters. These general results are used to design a fast noninteracting digital flight controls system for a typical STOL aircraft. Author

A87-35079#
ON THE STABILITY OF A VTOL SUPPORTED BY ONE-DUCTED-FAN (PRELIMINARY STUDY)
SHIGENORI ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 395, 1986, p. 671-677. In Japanese, with abstract in English. refs
Flying Platform, supported by a ducted fan(s), is a safe and simple airplane. The height of the vehicle CG from the ducted-fan aerodynamic center should be selected quite carefully, from the stability and control viewpoint. A simple design philosophy is presented, which makes the horizontal speed and the attitude uncouple. The vehicle is made neutrally stable, and the CG is located above the duct-aerodynamic-center by the order of duct inner diameter. This design philosophy would also make the vehicle safe against horizontal gust. A preliminary numerical example is presented by using available (somewhat incomplete) data. Author

N87-20288 Princeton Univ., N. J.
STABILITY REGIONS OF RELAXED STATIC STABILITY AIRCRAFT UNDER CONTROL SATURATION CONSTRAINTS Ph.D. Thesis
PRAKASH CHANDRA SHRIVASTAVA 1986 550 p
Avail: Univ. Microfilms Order No. DA8626183
Gains can be achieved in maneuvering performance and cruising flight fuel use if an aircraft is designed with low inherent stability. Limitations imposed by constraints on magnitudes and rates of control surface deflections on regions of stable operation of unstable aircraft are exposed. Shapes and sizes of stability regions are shown to depend upon types of singularities, feedback gains, control saturation limits, and command inputs. Analytical expressions for stability regions are possible only as special cases. Higher feedback gains increase sizes of stability regions. For non-zero commands, the stability regions of systems with saddle-point- and unstable-node-type singularities disappear when control deflections exceed saturation limits for desired command.

Such is not the case for systems with unstable-focus-type singularities where with increasing commands, an inner limit cycle emerges within outer stability boundary, and it grows in size with commands until the two boundaries coincide. Effects of joint rate and displacement saturation are examined by a saddle-point-type singularity. Stability regions in phase plane of the control and unstable mode are found to be unstable limit cycles. Bandwidths have little influence on their sizes, which increase almost proportionately with rate limits. Upon imposition of displacement limits size reduction is considerable, and the size cannot be increased by increasing rate limits beyond a certain point. Larger stability regions result when control deflection is also fed back, and smaller regions are obtained when feedback gain is increased. Dissert. Abstr.

N87-20289*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
ANALYSIS OF NLR CONFIGURATIONS USING OCM FOR PILOT MODELING Interim Status Report
M. H. DRAJESKE 28 Apr. 1987 108 p
(Contract NAG4-1)
(NASA-CR-180656; NAS 1.26:180656) Avail: NTIS HC A06/MF A01 CSCL 01C

A summary of the results obtained from an analytic handling qualities analysis of the rate-command/attitude-hold aircraft configurations is presented. Pilot/vehicle performance was evaluated using an optimal control technique for pilot modeling. Numerical and graphical results for a closed-loop frequency-domain analysis are presented and discussed and comparisons with experimental results are made. Finally, the results are compared with those from another study that dealt with similar configurations. B.G.

N87-20290*# Boeing Commercial Airplane Co., Seattle, Wash.
DESIGN AND VERIFICATION BY NONLINEAR SIMULATION OF A MACH/CAS CONTROL LAW FOR THE NASA TCV B737 AIRCRAFT Final Report
KEVIN R. BRUCE Dec. 1986 68 p
(Contract NAS1-14880)
(NASA-CR-178029; NAS 1.26:178029) Avail: NTIS HC A04/MF A01 CSCL 01C

A Mach/CAS control system using an elevator was designed and developed for use on the NASA TCV B737 aircraft to support research in profile descent procedures and approach energy management. The system was designed using linear analysis techniques primarily. The results were confirmed and the system validated at additional flight conditions using a nonlinear 737 aircraft simulation. All design requirements were satisfied. Author

N87-20292# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
EFFECT OF DYNAMIC STALL AND ELASTIC PARAMETERS ON THE FUNDAMENTAL MECHANISMS OF HELICOPTER VIBRATIONS Final Report, 1 Sep. 1985 - 30 Sep. 1986
DAVID A. PETERS 1 Nov. 1986 82 p
(Contract DAAG29-85-K-0228)
(AD-A175561; ARO-23322.7-EG) Avail: NTIS HC A05/MF A01 CSCL 01C

This research has dealt with the modeling and solution of rotary-wing dynamics. In the modeling area, it deals with elastic-blade models, ways to introduce rotor-body coupling, aerodynamic behavior near blade-tips, and the modeling of dynamic stall. In solution strategies, we have concentrated on new and improved Floquet methods, on innovative trim methodologies (such as auto-pilot and periodic shooting), on efficient formulation of equations, and on lifting -line and lifting-surface meshes. GRA

N87-20293# Royal Air Force Coll., Cranwell (England).
SIMULATION OF AN INTEGRATED FIRE AND FLIGHT CONTROL SYSTEM FOR AIR-TO-AIR GUNNERY M.S. Thesis
D. R. SMITH 1986 158 p
(ETN-87-99479) Avail: NTIS HC A08/MF A01

A FORTRAN simulation of an integrated fire and flight control (IFFC) system was developed, based on the configuration of the Firefly system tested in an F-15B. The model simulates only the pitch channel of the system, using a simplified form of the short period pitching oscillation state equation. A choice of three forms of stability augmentation brings the basic aircraft dynamic characteristics within the Defense Standard limits. Because the model is assumed to have a fixed gun installation, the aircraft must itself be maneuvered to achieve correct weapon aiming and the overall system is therefore subject to kinematic closure. Simulations show that IFFC is a viable concept for new aircraft and for retrospective inclusion on existing types. There may not always be direct benefits in aiming accuracy, but IFC should result in a significant reduction in the pilot's workload, an enlargement of the engagement envelopes, and potentially an improvement in the overall cost-effectiveness of the complete weapons system. ESA

N87-20999* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRPLANE AUTOMATIC CONTROL FORCE TRIMMING DEVICE FOR ASYMMETRIC ENGINE FAILURES Patent
ERIC C. STEWART, inventor (to NASA) 10 Mar. 1987 7 p
Filed 23 Oct. 1985 Supersedes N86-20397 (24 - 11, p 1720)
(NASA-CASE-LAR-13280-1; US-PATENT-4,648,569; US-PATENT-APPL-SN-790556; US-PATENT-CLASS-244-76-R; US-PATENT-CLASS-340-967) Avail: US Patent and Trademark Office CSCL 01C

The difference in dynamic pressure in the propeller slipstreams as measured by sensors is divided by the freestream dynamic pressure generating a quantity proportional to the differential thrust coefficient. This quantity is used to command an electric trim motor to change the position of trim tab thereby retrimming the airplane to the new asymmetric power condition. The change in position of the trim tab produced by the electric trim motor is summed with the pilot's input to produce the actual trim tab position. Official Gazette of the U.S. Patent and Trademark Office

N87-21000# Royal Aircraft Establishment, Farnborough (England).
DIVERGENCE AND FLUTTER OF SWEPT-FORWARD WINGS WITH CROSSFLEXIBILITIES
LL. T. NIBLETT Apr. 1980 38 p
(RAE-TR-80047; RAE-STRUCT/BF/B/0816; BR75315; ETN-87-99812) Avail: NTIS HC A03/MF A01

The divergence and flutter of swept forward wings whose flexural and torsional displacements are coupled by crossflexibility were investigated. It is found that the effect of crossflexibility on divergence speed is reduced as the flexural flexibility is increased, the torsional flexibility being maintained constant. The presence of crossflexibility is unlikely to introduce serious flutter problems. Crossflexibility can be obtained by using fiber composites with asymmetric ply layups. The analysis of Mansfield (1979) applicable for wings of moderately-high and high aspect ratio, was used to relate asymmetry of layup and crossflexibility. ESA

N87-21001# Test Wing (4950th), Wright-Patterson AFB, Ohio.
ADVANCED ELECTROMECHANICAL ACTUATION SYSTEM (EMAS), FLIGHT TEST Final Report, Jul. 1985 - Mar. 1986
WILLIAM J. NORTON Jun. 1986 139 p
(AD-A176148; REPT-4950-FTR-86-4) Avail: NTIS HC A07/MF A01 CSCL 01C

The EMAS flight test project successfully demonstrated, for the first time, the electrical actuation of a primary flight control surface in flight. This test was a major step toward the realization of the All-Electric Airplane (AEA) concept. An electric actuator was installed in a modified C-141A aircraft to power the left aileron. Testing included ground and flight trials to ensure unchanged

control system damping. Aircraft roll performance tests included maximum effort rolls, degraded system rolls, and autopilot rolls. Sideslip and trim test points were also performed. It was verified that EMAS performance was similar to the normal hydraulic actuator. Results include lessons on aircraft modification, general system characteristics, maintenance factors, and compatibility with other aircraft systems that may influence future installations. GRA

N87-21002# Aeronautical Research Labs., Melbourne (Australia).
STATE CONSTRAINTS FOR PREDICTIVE CONTROL WITH AIR VEHICLE APPLICATION Systems Technical Memorandum
C. R. GUY Apr. 1986 33 p
(AD-A176205; ARL-SYS-TM-88) Avail: NTIS HC A03/MF A01 CSCL 01D

The object of a predictive controller is to move the states of a plant from some finite initial conditions to some finite end conditions in a time-optimal, or sub-time-optimal way. To do this the plant is driven in an on-off manner; the controller calculates when the plant drive direction should be switched to give suitable control. The constraint algorithms allow such control to proceed while simultaneously enabling any state or combination of states to be restricted to a prescribed level. Algorithms are outlined for putting hard constraints on the values of the state variables in a system controlled using predictive (fast model) techniques and are applied to an air flight trajectory problem. Two algorithms are described, the first dealing with restrictions on the Nth state of an Nth order system and the second dealing with restrictions on the remaining state variables. To comprehend the constraint procedure, the principles of predictive control are briefly described with the aid of time history plots and phase plane portraits. Results are presented for constraints simultaneously applied to variables in a third order system and for a trajectory problem. The constraint algorithms are independent of the predictive control strategy. GRA

N87-21003# Aeronautical Research Labs., Melbourne (Australia).
ANALYSIS OF VIBRATION DATA FROM WHL (WESTLAND HELICOPTERS LIMITED) WESSEX FATIGUE TEST TRIAL 3
P. D. MCFADDEN Aug. 1986 30 p
(AD-A176208; ARL/AERO-PROP-TM-436) Avail: NTIS HC A03/MF A01 CSCL 01C

Broad band and narrow band enhancement and demodulation techniques are applied to the analysis of the signal averages of the vibration of the input spiral bevel pinion in a Wessex helicopter gearbox measured during a fatigue test. It is shown that the narrow band enhancement technique may be more sensitive to the presence of a crack in the gear than the broad band technique. It is confirmed that, as the affected teeth mesh, a phase lag in the vibration is produced which may be detected by narrow band demodulation. GRA

N87-21004# Naval Postgraduate School, Monterey, Calif.
DEVELOPMENT OF A MATHEMATICAL MODEL THAT SIMULATES THE LONGITUDINAL, AND LATERAL-DIRECTIONAL RESPONSE OF THE F/A-18 FOR THE STUDY OF FLIGHT CONTROL RECONFIGURATION M.S. Thesis
FREDRIC W. ROJEK Sep. 1986 286 p
(AD-A176333) Avail: NTIS HC A13/MF A01 CSCL 01C

A linearized mathematical model is developed which simulates the dynamic response of the Navy F/A-18 for the study of flight control reconfiguration. The aircraft is modeled as a multi-input multi-output, sampled data, closed system, which couples the dynamics of the flight control system to the aircraft linearized small perturbation equations. The discrete time, state variable equations for the system are then formulated. A computer program is developed which will compose the model matrices and compute the response of the aircraft to stick and rudder inputs. To study flight control reconfiguration, the model allows individual actuation of either a left or right control surface. Aircraft response to the actuation loss of either the left or right stabilator is simulated in the program. The program is designed to implement the reconfigurable control mixer, currently under study for the Self-Repairing Digital Flight Control System. The computer simulation was written in VS FORTRAN. A copy of the program and simulation results are included in the appendices. GRA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

A87-31473
USE OF MICROPROCESSOR ELEMENTS IN SIMULATION OF DIGITAL AVIONIC SYSTEMS
E. MANOUSSAKIS, J. V. SVOBODA, G. M. MCKINNON, and F. PETRUZZIELO (Concordia University, Montreal, Canada) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 185-189.
(Contract NSERC-PRAI-P-8108)

Design of microprocessor based avionic systems is the current state-of-the-art in civil and military aviation engineering. High reliability, reasonable development cost and design flexibility are ideal features that enable avionics manufacturers to produce powerful and very reliable equipment. This paper presents the results of experimental research in simulation of digitally controlled avionic systems using microprocessors. This research is part of a development effort toward an advanced general aviation instrument flight rules (IFR) simulation system. The current microprocessor technology is supportive of such training equipment design and development. Author

A87-31474
A GENERIC METHODOLOGY FOR PASSIVE SENSOR AVIONICS EMULATION IN MAN-IN-THE-LOOP COCKPIT SIMULATORS
KYLE ISAKSON (Bell Helicopter Textron, Fort Worth, TX) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 190-195. refs

Ground based man-in-the-loop simulation is becoming increasingly important in the evaluation and testing of advanced cockpits and associated avionics suites. In the future the availability to prototype expert systems using simulations is a desirable goal. This paper addresses a real-time sensor emulation capable of interfacing with a target database containing up to 256 targets (up to 32 at any one time). The generic approach taken in this simulation: (1) increases the fidelity and relevance of the simulation of the proposed design, (2) allows for evaluation of the actual mission computer algorithms in the flight simulator early in the development process, and (3) can reduce the duplication of effort in the software development task both for the actual aircraft and the flight simulator. Author

A87-31476
AVIONICS SYSTEM DEVELOPMENT IN A GROUND BASED LABORATORY ENVIRONMENT
RICHARD A. WEEKS (VERAC, Inc., San Diego, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 204-208.

This paper describes the utilization of ground-based laboratories for the development of complex, highly-integrated avionics systems. Concept development laboratories, full-mission flight/mission simulator laboratories, and various avionics integration laboratories are discussed to substantiate the need of a systematic approach to avionics development in a ground-based laboratory environment. Author

A87-31478
A HARDWARE AND SOFTWARE INTEGRATION FACILITY (HSIF) FOR SH-60F CV-HELO
PATRICK J. DONOGHUE, PREBEN JENSEN, and ROBERT M. PEABODY (Teledyne Systems Co., Northridge, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 212-218.

This paper discusses the requirements, development, and use of a mobile Hardware and Software Integration Facility (HSIF) which has been developed to support the mission avionics of a carrier based anti-submarine warfare helicopter, namely the SH-60F DV-Helo. The HSIF supports the full life-cycle of the avionics system including initial development, system integration, flight test, customer (Navy) test and evaluation, and fleet operations. The facility uses a DEC VAX 11/785 for central processing and Motorola 68000 Based VME Modules for avionics control. It has full capabilities for stimulation and testing at the box or WRA level, flight software development and download, stimulation of the mission avionics with simulated mission scenarios, and data reduction and analysis of collected information. Author

A87-31520
EVALUATION OF PROTOTYPE DIGITAL FLIGHT CONTROL ALGORITHMS IN HARDWARE-IN-THE-LOOP ENVIRONMENT
G. K. NEIDERS, A. S. GOLDSTEIN, and J. E. DAVIDSON (Boeing Aerospace Co., Seattle, WA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 547-554.

To minimize development risk, early evaluation digital flight control algorithms is essential in the design of a missile flight control system. To minimize cost and time, these algorithms need to be evaluated in flight tests but can be coded on a prototype flight computer and tested in a hardware-in-the-loop, real-time simulation environment. This type of testing presents a more realistic environment than an all-software simulation. The hardware typically included in the simulation is a prototype flight computer with the digital flight control algorithms coded, an inertial measurement unit (IMU) mounted on a motion table, and fin actuator units (FAU's) connected to dynamic loading fixtures that simulate the actual flight loads. This paper discusses one such hardware-in-the-loop test which was performed to test a proposed digital flight control system. The tests proved to be useful and successful. Included in this paper are a description of the building of the hardware/software test bed, the evolutionary process of integrating the test hardware and software with the flight hardware and softare, and a summary of the results of the tests. Author

A87-31545
DEVELOPMENT OF A DIGITAL/ANALOGUE ELECTRONIC FLIGHT INSTRUMENTATION SYSTEM (EFIS) SIMULATION
E. C. MANOUSSAKIS and A. R. VEGH (Flightsafety Canada, Ltd., Montreal, Canada) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 743-750. refs

Dedicated Electronic Flight Instrumentation (EFIS) training systems are required for in-depth flight crew familiarization, in addition to regular synthetic flight training. Novel cockpit system concepts create demands for advanced training aids that are to be dealt with adequately. This paper discusses a design effort undertaken toward a combination of digital and analogue Electronic Flight Instrumentation Systems training, with Flight Management and Instruction Control capabilities. The simulation system in discussion is being developed for jet aircraft flight crew training. Author

A87-31724
A SYSTEM OF PROBLEMS IN THE DESIGN OF COMPUTER-AIDED PROCESSES FOR THE GROUND TESTING OF AVIATION EQUIPMENT [SISTEMA ZADACH PROEKTIROVANIIA AUTOMATIZIROVANNYKH TEKHNOLOGICHESKIKH PROTSESSOV NAZEMNYKH ISPYTANII IZDELII AVIATSIONNOI TEKHNIKI]
A. Z. VALITOV and V. S. MOISEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 23-27. In Russian. refs

The design of computer-aided testing processes for aviation systems is treated as solving, by means of an iteration procedure, a set of fundamental problems. These include: selection of the principal testing stages to be computerized; selection of the parameters to be measured; definition of the sequence and content of testing processes; and selection of testing apparatus and instrumentation. Attention is also given to such problems as calculation of the test cycle and its mean duration, the structure and organization of test sites, and the production of design documentation. V.L.

A87-32194#
THE RESEARCH OF 2-D FLEXIBLE WALL SELF-STREAMLINING WIND TUNNEL
JIAJU HE and PEICHU ZUO (Northwestern Polytechnical University, Xian, People's Republic of China) Asian Congress of Fluid Mechanics, 3rd, Tokyo, Japan, Sept. 1-5, 1986, Paper. 4 p. refs

Results are presented from theoretical modeling and experimental tests of a wind tunnel design which would control wall interference effects. It was decided to use flexible walls and actively contour the upper and bottom walls to correct the freestream for expected boundary layer displacements. Nineteen jacks and several pressure taps were installed for each wall. The pressure data, incorporated into a displacement model, generated data for guiding the tunnel walls in automated adaptation to maintain an unperturbed freestream flowfield. Sample test results with a NACA 0012 airfoil are provided to illustrate the satisfactory performance of the self-adapting walls, particularly for lowering the Reynolds number in a small wind tunnel. M.S.K.

A87-32577*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TIRE AND RUNWAY SURFACE RESEARCH
THOMAS J. YAGER (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 24 p. refs
(SAE PAPER 861618)

The condition of aircraft tires and runway surfaces can be crucial in meeting the stringent demands of aircraft ground operations, particularly under adverse weather conditions. Gaining a better understanding of the factors influencing the tire/pavement interface is the aim of several ongoing NASA Langley research programs which are described in this paper. Results from several studies conducted at the Langley Aircraft Landing Dynamics Facility, tests with instrumented ground vehicles and aircraft, and some recent aircraft accident investigations are summarized to indicate effects of different tire and runway properties. The Joint FAA/NASA Runway Friction Program is described together with some preliminary test findings. The scope of future NASA Langley research directed towards solving aircraft ground operational problems related to the tire/pavement interface is given. Author

A87-32582* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLOW RATE AND TRAJECTORY OF WATER SPRAY PRODUCED BY AN AIRCRAFT TIRE
ROBERT H. DAUGHERTY and SANDY M. STUBBS (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 9 p.
(SAE PAPER 861626)

One of the risks associated with wet runway aircraft operation is the ingestion of water spray produced by an aircraft's tires into its engines. This problem can be especially dangerous at or near

rotation speed on the takeoff roll. An experimental investigation was conducted in the NASA Langley Research Center Hydrodynamics Research Facility to measure the flow rate and trajectory of water spray produced by an aircraft nose tire operating on a flooded runway. The effects of various parameters on the spray patterns including distance aft of nosewheel, speed, load, and water depth were evaluated. Variations in the spray pattern caused by the airflow about primary structure such as the fuselage and wing are discussed. A discussion of events in and near the tire footprint concerning spray generation is included. Author

A87-32583
ALTERNATE LAUNCH AND RECOVERY SURFACE TRACTION CHARACTERISTICS
THOMAS J. CARTER, DAVID H. TREANOR (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and MARTIN D. LEWIS (USAF, Engineering Services Center, Tyndall AFB, FL) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p.
(SAE PAPER 861627)

The rapid repair of bomb-damaged runways is of increasing concern to the U.S. Air Force, therefore, expedient repair concepts are being developed. Aircraft performance effects imposed by the repair treatments include: tire flotation, aircraft weight, landing dynamics, and the forces generated at the tire/runway surface interface. This study focuses on tire/runway surface interface forces and was initiated to evaluate several surfaces with respect to their relative tractive and lateral force potential. Three damage repair surface materials, a baseline concrete surface, and a ceramic aluminized marking strip were tested. Quasi-static tests were run at seven tire yaw angles, with and without braking under dry, wet, and icy conditions. Author

A87-32590
STATE-OF-THE-ART OF GROUND AIRCRAFT DEICING TECHNOLOGY
DEBORAH MAYER (Arinc Research Corp., Annapolis, MD) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 15 p. refs
(SAE PAPER 861656)

This paper provides an update of operational, procedural, and systems information regarding on ground deicing and anti-icing of aircraft certified for Federal Aviation Regulations (FAR) parts 91, 121, 135 operations. The data presented reflects general aviation and the airlines' perception of the clean aircraft concept and highlights the need for an increased awareness of the various types of deicing fluids and facilities available. Two important issues surrounding the aircraft deicing fluids (ADFs) used in North America and Europe are addressed. First, the Federal Aviation Administration's (FAA's) Advisory Circular (AC) 20-117 stresses the clean aircraft concept which some members of the deicing community argue is violated by the Association of European Airline's (AEA's) Type II thixotropic ADFs. Second, the environmental and health effects which may result from the various glycols contained in ADFs is the subject of some debate in the North American and European deicing community. Author

A87-32592
ROBOTIC TECHNOLOGY FOR GROUND SUPPORT EQUIPMENT YIELDS HIGH PERFORMANCE AND RELIABILITY
CHRIS P. ROSS (Ipeco Europe, Ltd., Airlec Div., Hayes, England) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p.
(SAE PAPER 861658)

This paper will report on a major initiative in the field of both the design of electric airport equipment and the technology applied. It will demonstrate the dramatic effect on energy saving that the design approach affords and will illustrate just some of the advantages of incorporating advanced electronic technologies in airport equipment products. A battery-powered 15,000-pound lower deck pallet loader has been designed and manufactured combining direct mechanical transmissions and a microprocessor-based intelligent control. The effect is to give the machine a performance and daily range comparable to and in some respects exceeding, its i.c.-engined alternatives. Author

A87-34768
TOWARDS TOTAL SIMULATION
GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 131, Feb. 21, 1987, p. 42-46, 49, 50, 52.

The state-of-the-art airliner pilot training flight simulation facilities presently compared all offer greater scene detail than their predecessors, with three-dimensional texturing and such sophisticated visual effects as luminosity, transparency, shading, and movement. Weather can be convincingly portrayed, with objects emerging from fog during low visibility condition simulations. This year will witness the delivery of the first simulators incorporating distributed processing techniques, which enhance realism. It is noted that greater fidelity to flight conditions in simulation has inexorably led to greater system costs; a number of airlines have attempted to minimize costs through the use of fixed-base simulators lacking motion and visual systems for their pilot training. O.C.

N87-20294*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONS FOR THE 16-FOOT TRANSONIC TUNNEL, NASA, LANGLEY RESEARCH CENTER, REVISION 1
CHARLES E. MERCER, BOBBY L. BERRIER, FRANCIS J. CAPONE, ALAN M. GRAYSTON (Wyle Labs., Inc., Hampton, Va.), and C. D. SHERMAN Jan. 1987 204 p
(NASA-TM-86319-REV-1; NAS 1.15:86319-REV-1) Avail: NTIS HC A10/MF A01 CSCL 14B

The equations used by the 16 foot transonic tunnel in the data reduction programs are presented in eight modules. Each module consists of equations necessary to achieve a specific purpose. These modules are categorized in the following groups: tunnel parameters; jet exhaust measurements; skin friction drag; balance loads and model attitudes calculations; internal drag (or exit-flow distributions); pressure coefficients and integrated forces; thrust removal options; and turboprop options. This document is a companion document to NASA TM-83186, A User's Guide to the Langley 16 Foot Transonic Tunnel, August 1981. Author

N87-20295*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETAILED FLOW SURVEYS OF TURNING VANES DESIGNED FOR A 0.1-SCALE MODEL OF NASA LEWIS RESEARCH CENTER'S PROPOSED ALTITUDE WIND TUNNEL
ROYCE D. MOORE, RICKEY J. SHYNE, DONALD R. BOLDMAN, and THOMAS F. GELDER Apr. 1987 151 p
(NASA-TP-2680; E-3294; NAS 1.60:2680) Avail: NTIS HC A08/MF A01 CSCL 14B

Detailed flow surveys downstream of the corner turning vanes and downstream of the fan inlet guide vanes have been obtained in a 0.1-scale model of the NASA Lewis Research Center's proposed Altitude Wind Tunnel. Two turning vane designs were evaluated in both corners 1 and 2 (the corners between the test section and the drive fan). Vane A was a controlled-diffusion airfoil and vane B was a circular-arc airfoil. At given flows the turning vane wakes were surveyed to determine the vane pressure losses. For both corners the vane A turning vane configuration gave lower losses than the vane B configuration in the regions where the flow regime should be representative of two-dimensional flow. For both vane sets the vane loss coefficient increased rapidly near the walls. Author

N87-20296*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL ANALYSIS AND PRELIMINARY REDESIGN OF THE NOZZLE CONTOUR OF THE LANGLEY HYPERSONIC CF4 TUNNEL
R. A. THOMPSON and KENNETH SUTTON Mar. 1987 32 p
(NASA-TM-89042; L-16170; NAS 1.15:89042) Avail: NTIS HC A03/MF A01 CSCL 14B

A computational analysis, modification, and preliminary redesign study was performed on the nozzle contour of the Langley Hypersonic CF4 Tunnel. This study showed that the existing nozzle was contoured incorrectly for the design operating condition, and this error was shown to produce the measured disturbances in the exit flow field. A modified contour was designed for the current nozzle downstream of the maximum turning point that would provide a uniform exit flow. New nozzle contours were also designed for an exit Mach number and Reynolds number combination which matches that attainable in the Langley 20-Inch Mach 6 Tunnel. Two nozzle contours were designed: one having the same exit radius but a larger mass flow rate than that of the existing CF4 Tunnel, and the other having the same mass flow rate but a smaller exit radius than that of the existing CF4 Tunnel. Author

N87-20297*# General Dynamics/Convair, San Diego, Calif.
DESIGN STUDY OF ADVANCED MODEL SUPPORT SYSTEMS FOR THE NATIONAL TRANSONIC FACILITY (NTF)
Jan. 1987 68 p
(Contract NASA ORDER L-997258)
(NASA-CR-178214; NAS 1.26:178214) Avail: NTIS HC A04/MF A01 CSCL 14B

It has long been recognized that the sting (or support system) is a very critical part of the model system. The designer is frequently faced with the tradeoff of minimizing sting size, thereby compromising facility and model safety, against a larger sting and the subsequent problems of sting interference effects. In the NASA Langley Research Center National Transonic Facility (NTF), this problem is accentuated by the severe environment of high pressure/low temperature, designed into the facility to provide the desired high Reynolds number. Compromises in the configuration geometry and/or limiting the test envelope are therefore contrary to the purposes and goals of the NTF and are unacceptable. The results of an investigation aimed at improvements of 25% in both strength and Young's modulus of elasticity as compared to high strength cryogenically acceptable steels currently being used are presented. Various materials or combinations of materials were studied along with different design approaches. Design concepts were developed which included conventional material stings, advanced composites, and hybrid configurations. Candidate configurations are recommended. Author

N87-20298*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VISUAL DISPLAY AND ALARM SYSTEM FOR WIND TUNNEL STATIC AND DYNAMIC LOADS
RICHARD D. HANLY and JAMES T. FOGARTY (Raman Aeronautics Research and Engineering, Inc., Palo Alto, Calif.) Apr. 1987 10 p
(NASA-TM-89455; A-87105; NAS 1.15:89455) Avail: NTIS HC A02/MF A01 CSCL 14B

A wind tunnel balance monitor and alarm system developed at NASA Ames Research Center will produce several beneficial results. The costs of wind tunnel delays because of inadvertent balance damage and the costs of balance repair or replacement can be greatly reduced or eliminated with better real-time information on the balance static and dynamic loading. The wind tunnel itself will have enhanced utility with the elimination of overly cautious limits on test conditions. The microprocessor-based system features automatic scaling and 16 multicolored LED bargraphs to indicate both static and dynamic components of the signals from eight individual channels. Five individually programmable alarm levels are available with relay closures for internal or external visual and audible warning devices and other functions such as automatic activation of external recording devices, model positioning mechanisms, or tunnel shutdown. Author

N87-20299# Bristol Univ. (England). Dept. of Aeronautical Engineering.
AN INVESTIGATION INTO THE FACTORS AFFECTING THE FLOW QUALITY IN A SMALL SUCTION WIND TUNNEL B.S. Thesis
S. E. B. LAWSON and A. P. R. STEWART Jun. 1986 46 p
(BU-344; ETN-87-99206) Avail: NTIS HC A03/MF A01

During testing of a wind tunnel designed to allow investigation of the dynamic interference on an airfoil, it was found that the tunnel itself was subject to large flow disturbances sufficient to prevent accurate measurements of the effects. Changes to the tunnel were made in order to investigate their relative contributions to turbulence alleviation. Measurements with a hot-wire probe system show that the turbulence can be reduced to under 0.7% by a combination of these changes. However, it is also shown that disturbances from the suction fan are a major cause of the tunnel turbulence and thus suggest that the tunnel/fan combination may not be suitable for measurement of the dynamic interference effects as originally intended. ESA

N87-20300# European Space Agency, Paris (France).
THE HIGH-SPEED CASCADE WIND TUNNEL - STILL AN IMPORTANT TEST FACILITY FOR TURBOMACHINERY BLADE INVESTIGATIONS
HEINZ HOHEISEL Nov. 1986 37 p Transl. into ENGLISH of "Der Hochgeschwindigkeits-Gitterwindkanel - Immernoch eine Wichtige Versuchsanlage fuer Untersuchungen an Turbomaschinenbeschaufellungen" DFVLR, Brunswick, West Gemany, report DFVLR-Mitt-86-11, Mar. 1986 Original language document was announced as N87-10878
(ESA-TT-1012; DFVRL-MITT-86-11; ETN-87-99430) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne, West Germany DM 14

The importance of the high speed cascade wind tunnel was demonstrated. Starting from the conception of this wind tunnel and the requirements for cascade wind tunnels in which compressible flows have to be studied, the usability and qualification of this test facility for research work is described with examples of turbine and compressor cascade investigations. Necessary additional equipment is discussed. ESA

N87-21005# Smiths Industries Ltd., Bishops Cleeve (England). Aerospace and Defence Systems.
ELECTRONIC DISPLAY EQUIPMENT FOR USE IN THE ADVANCED FLIGHT DECK SIMULATOR AT BRITISH AEROSPACE, WEYBRIDGE Final Report
A. J. POPLE Apr. 1986 18 p
(Contract MOD(PE)-A81A/1992)
(RID-1912; BR-99557; ETN-87-99455) Avail: NTIS HC A02/MF A01

Full color electronic display equipment was designed and constructed and installed in a flight deck simulator. A side-by-side arrangement of units was compared with the conventional vertical arrangement. ESA

N87-21007 Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ACTIVITIES REPORT OF THE LARGE TESTING FACILITIES Annual Report, 1985
Oct. 1986 27 p
(ETN-87-99376) Avail: NTIS HC A03/MF A01

Wind tunnel tests of the ACX Rafale fighter aircraft, of a transonic propeller, and of a transport aircraft; automatic systems, pressure measurements, and synthetic result displays; preparation of wind tunnel tests on motorized models with turbine-power simulators (TPS); extension of TPS calibration bench to reverse tests; rotary rake for probing the field around air intakes and determining the external drag; an air duct explorer; a supersonic variable-Mach nozzle for a wind tunnel; CAD software; and wind tunnel tests of a sailpower liner are summarized. ESA

N87-21192# Royal Aircraft Establishment, Farnborough (England).
DEVELOPMENTS IN DATA ACQUISITION AND PROCESSING USING AN ADVANCED COMBUSTION RESEARCH FACILITY
J. B. BULLARD, F. S. E. WHITCHER, and R. V. STEEDEN *In* AGARD Advanced Instrumentation for Aero Engine Components 16 p Nov. 1986 Previously announced as N87-16852
Avail: NTIS HC A24/MF A01

A new combustion rig is described which is designed to acquire rapid and detailed information on the combustion processes occurring within a sector of large annular gas turbine combustors operating over a range of inlet pressures and temperature representative of engine conditions. Gas samples are extracted using a probe positioned within the volume under examination and transferred to a system designed to perform analyses with a point-to-point cycle time of less than 30 seconds. A computer is used to used to control and synchronize the probe positioning and gas analysis function and to present co-ordinated results to rig controllers. The system is capable of automatic traversing within a prescribed volume or of control by a dummy traverse gear which permits tracing of air and fuel flows. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications; spacecraft communications; command and tracking; spacecraftdesign; testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A87-32559
A MICROGRAVITY EXPERIMENT TO MEASURE SURFACE FORCES AND SURFACE ENERGIES IN SOLIDS
GIULIO POLETTI (Milano, Universita, Milan, Italy) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 2117-2125. CNR-supported research.

A dynamic experiment on surface forces in contacting solids has been performed in microgravity conditions on board of the KC-135 aircraft of NASA within a Parabolic Flight Mission performed as a NASA-ESA joint venture. After an outline of the experiment and its objectives, a short discussion is given concerning the facility, which has been released to free float inside the cabin of the aircraft to guarantee the best microgravity conditions. The features of the contact force are quite different from that measured on the ground and the contact time is much longer than expected from theory. The preliminary results are compared with the results from a computer simulation. By means of this experiment surface forces in contacting solids have been measured for the first time. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

A87-31373
COMPOSITES FOR AEROSPACE DRY BEARING APPLICATIONS
JOHN K. LANCASTER (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) IN: Friction and wear of polymer composites . Amsterdam and New York, Elsevier, 1986, p. 363-396. refs

Most bearings associated with flight-control applications in fixed wing aircraft and helicopters comprise polymer-based composites in the form of thin layers, about 0.3 mm thick, adhesively bonded to a metal substrate. The various types of composite used for this purpose are described and information given on how their friction and wear properties depend on the conditions of sliding; stress, temperature, counterface metal, contamination by fluids, type of loading, and various kinematic factors associated with the bearing design. A long-standing objective has been to relate friction and wear performance to composite structures and compositions and some results are given from recent research describing progress toward this end. Finally, brief mention is made of future trends and requirements for composites in dry-bearings, with particular reference to high temperature applications. Author

A87-31379
NEW RAPIDLY SOLIDIFIED TITANIUM ALLOYS PRODUCED BY MELT-SPINNING
RANJAN RAY and PETER CLEMM (Marko Materials, Inc., North Billerica, MA) IN: Titanium rapid solidification technology; Proceedings of the Symposium, New Orleans, LA, Mar. 2-6, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 57-68. refs

The principles of rapid solidification processing were used to fabricate microcrystalline titanium alloys containing finely dispersed boride phases. Chill block casting was used to prepare filaments of three titanium alloys, Ti-6Al-4V, Ti-8Al-1Mo-1V, and Ti3Al each alloyed additionally with 1 weight percent boron. The filaments were pulverized into 60 mesh powder by a rotating hammer mill. The powders were subsequently consolidated into bar stock by hot extrusion. The alloys were tested for tensile properties at room and elevated temperatures. Microstructural investigation of the alloys were carried out using TEM and STEM techniques. The results of this study are presented. Author

A87-31385
CHARACTERISTICS OF OXIDE DISPERSIONS IN RAPIDLY SOLIDIFIED TITANIUM ALLOYS
R. E. ANDERSON and J. L. LARSON (Pratt and Whitney, Engineering Div., West Palm Beach, FL) IN: Titanium rapid solidification technology; Proceedings of the Symposium, New Orleans, LA, Mar. 2-6, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 121-129. refs
(Contract F33615-85-C-5067)

Many studies have shown that rapidly solidified titanium alloys with rare earth elemental additions yield fine dispersions of rare earth oxides. These dispersions have potential for property enhancement in conventional as well as novel alloys. Rapidly solidified powder was produced and characterized of conventional alloys with erbium additions. The particulate was screened to several size fractions and vacuum hot compacted. The resulting dispersions in each size fraction were evaluated according to average diameter, spacing, volume percent, and thermal stability. Author

A87-31388
RARE EARTH OXIDE DISPERSIONS IN RAPIDLY SOLIDIFIED TITANIUM-ALUMINUM ALLOYS
DAVID B. SNOW and ANTHONY F. GIAMEI (United Technologies Research Center, East Hartford, CT) IN: Titanium rapid solidification technology; Proceedings of the Symposium, New Orleans, LA, Mar. 2-6, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 153-164. refs
(Contract N00014-85-C-0426)

Significant potential exists for the improvement of creep strength by dispersion strengthening in rapidly solidified titanium alloys to which rare earth elements have been added. The relative effectiveness with which several different rare earth elements form oxide dispersions in splat quenched Ti-Al solid solution was examined, using Ti-Al-Er as a base. The introduction of oxygen during alloy preparation was controlled by using components of known composition, and continuously gettered argon during arc melting, splat quenching and annealing. The crystal structure and spatial distribution of the dispersed phases in both as-quenched and aged specimens was determined by analytical transmission electron microscopy. The structure of the intercellular precipitates in Ti-Al-Er was that of cubic Er2O3, while both cubic and monoclinic rare earth sesquioxides were observed at intercellular sites in Ti-Al-Gd and Ti-Er-Dy. Most of the precipitates formed in both the Gd-, Tb-, and Er-containing alloys during aging at 800 C for 15 min were cubic 'Type I': lattice parameter less than that of the equilibrium sesquioxide. These rare earth suboxides (presumably) were faceted on (111) when viewed in the 11-2 direction, and were rectangular in profile with a maximum dimension of 35 nm. A few 'Type II' precipitates were also observed after aging, which had a lattice parameter equal to that of the equilibrium cubic sesquioxide. Author

A87-31399
POWDER METALLURGY OF TITANIUM ALUMINIDE COMPONENTS
C. F. YOLTON, T. LIZZI, V. K. CHANDHOK, and J. H. MOLL (3Crucible Research Center, Pittsburgh, PA) IN: Titanium rapid solidification technology; Proceedings of the Symposium, New Orleans, LA, Mar. 2-6, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 263-271. Research supported by Teledyne CAE and Crucible Materials Corp. refs

Titanium alloys based on intermetallic compounds in the titanium-aluminum binary system have attractive properties which make them excellent candidates for applications in gas turbine engines. These properties include good high temperature strength and ductility, good oxidation resistance and a low density. Titanium aluminide alloys can potentially be substituted for nickel-based alloys currewntly used at intermediate temperatures resulting in a substantial weight savings with no loss in performance. A niobium modified alpha two titanium aluminide alloy is one of the alloys under consideration. While this alloy has very attractive elevated temperature properties, it is a difficult alloy to hot work and fabricate into components. Powder metallurgy production of near-net shape components is one means of circumventing fabrication difficulties with this alloy. In this paper, several near-net shape components produced by the ceramic mold process using Plasma Rotating Electrode Process (PREP) powder are described. Room and elevated temperature mechanical properties of the powder metallurgy product are presented. Author

A87-31736
ANALYTICAL-EXPERIMENTAL DETERMINATION OF THE LONG-TERM STRENGTH OF GAS-TURBINE-ENGINE MATERIALS FOLLOWING TECHNOLOGICAL TREATMENTS [RASCHETNO-EKSPERIMENTAL'NAIA OTSENKA DLITEL'NOI PROCHNOSTI MATERIALOV GTD POSLE TEKNOLOGICHESKOI OBRABOTKI]
S. M. BOROVSKII and V. S. MUKHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 77-79. In Russian. refs

An analytical-experimental procedure for evaluating the long-term strength of gas-turbine-engine materials following technological treatments is developed on the basis of Rabotnov's (1979) theory which includes structural parameters characterizing the degree of damage and a system of nonholonomic differential equations describing the kinetics of damage. The method proposed here makes it possible to avoid time-consuming experiments and calculations. The discussion is illustrated by results for EP22OVD and EP866Sh high-temperature turbine alloys. V.L.

A87-31939
AN ANALYSIS OF THE FATIGUE FRACTURE OF THE ROTOR BLADES OF GAS TURBINE ENGINES OF CAST NICKEL-CHROMIUM ALLOYS OF THE ZHS TYPE [ANALIZ USTALOSTNOGO RAZRUSHENIIA RABOCHIKH LOPATOK GTD IZ LITEINYKH NIKEL'-KHROMOVYKH SPLAVOV TIPA ZHS]
I. A. MAKOVETSKAIA, O. I. MARUSII, B. A. GRIAZNOV, and IU. S. NALIMOV (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Jan. 1987, p. 46-50. In Russian. refs

The fracture behavior of rotor blades of Ni-Cr alloys of the ZhS series with different initial structures is investigated in the high-cycle region using metallographic and fractographic techniques. In both as-cast and heat treated blades, crack nucleation and stage I growth occur along a stable slip band in the (111) plane limited by one of the larger grains. Subsequently, the crack propagates in the plane of maximum tensile stresses. A relationship is established between the crystallographic orientation and the morphological features of the fracture surface. The effect of the service history on the characteristics of fatigue fracture is discussed. V.L.

A87-32032
CHARACTERIZATION AND MODELING OF THE HIGH TEMPERATURE FLOW BEHAVIOR OF ALUMINUM ALLOY 2024
B. C. STONE (Mead Corp., Miamisburg, OH), J. F. THOMAS, JR. (Wright State University, Dayton, OH), P. L. CHARPENTIER, and S. C. ERNST Metallurgical Transactions A - Physical Metallurgy and Materials Science (ISSN 0360-2133), vol. 17A, Dec. 1986, p. 2227-2237. refs
(Contract F33615-78-C-5025)

The flow behavior of aluminum alloy 2024-0 (containing, in wt pct, 4.9 Cu, 1.8 Mg, 0.9 Mn, 0.25 Zn, 0.5 Fe, 0.5 Si, and balance Al) was characterized over the temperatures of 145 to 482 C, and at 0.001 to 12.5/s constant true-strain rates using compression tests of cylindrical specimens and SEM for examination of microstructures. At 145 C, the isothermal flow curves exhibited strain hardening. At 250 C and above, the flow curves exhibited a peak followed by a flow softening. For the temperatures between 250 and 482 C, a constitutive equation was found that related the amount of softening to simple functions of temperature and strain. The observed as-deformed microstructures generally supported the idea that the flow softening in Al 2024-0 is associated with dynamic recovery. I.S.

A87-32084
SI3N4-SIC COMPOSITES
SERGEJ T. BULJAN, J. GARY BALDONI, and MARVIN L. HUCKABEE (GTE Laboratories, Inc., Waltham, MA) American Ceramic Society Bulletin (ISSN 0002-7812), vol. 66, Feb. 1987, p. 347-352. refs
(Contract DE-AC05-84OR-21400)

The effect of SiC particulate and whisker dispersoids on the fracture toughness and strength of Si3N4-based composites was evaluated. Addition of 30 vol pct SiC whiskers was observed to increase the fracture toughness of the Si3N4 by 40 percent, with concomitant strengthening of 25 percent. Microstructure-property relationships are discussed. Author

A87-32201

COMPOSITES USE IN AIRCRAFT WITH EMPHASIS ON KEVLAR ARIMIDE

PAUL R. LANGSTON (Du Pont de Nemours and Co., Inc., Wilmington, DE) Society of Manufacturing Engineers, Conference on Composites in Manufacturing, 5th, Los Angeles, CA, Jan. 13-16, 1986, Paper. 25 p.

The properties of Kevlar fibers are reviewed, along with current aerospace applications. Kevlar 29 and 49 fibers have a tensile strength five times that of steel, display a brittle response in tensile loading and exhibit plastic buckling when exposed to compressive loading, i.e., Kevlar fiber reinforced composites will bend like metals in flexural tests. The mechanical properties have shown little degradation under long exposure to outdoor moisture. Various configurations and design principles are described for honeycomb aircraft structures which combine Kevlar and Nomex. Filament wound rocket casings, pressure bottles, flotation gear, and commercial aircraft secondary structures are detailed, emphasizing the weight savings available with composite structures. M.S.K.

A87-33180

SOLID STATE PHASE TRANSFORMATIONS IN ALUMINIUM ALLOYS CONTAINING LITHIUM

H. M. FLOWER (Imperial College of Science and Technology, London, England) and P. J. GREGSON (Southampton, University, England) Materials Science and Technology (ISSN 0267-0836), vol. 3, Feb. 1987, p. 81-90. refs

The microstructure and solid state phase transformations which take place in aluminum alloys containing lithium have been assessed. In addition to the binary Al-Li system, the Al-Li-Cu, Al-Li-Mg, and Al-Li-Cu-Mg systems are discussed in detail together with the role of dispersoid forming elements. The physical metallurgical basis of current alloy development is thereby established. Author

A87-33265

THE DEVELOPMENT OF SINGLE CRYSTAL SUPERALLOY TURBINE BLADES

M. GELL and D. N. DUHL (Pratt and Whitney, East Hartford, CT) IN: Advanced high-temperature alloys: Processing and properties; Proceedings of the Nicholas J. Grant Symposium, Cambridge, MA, June 16-18, 1985 . Metals Park, OH, American Society for Metals, 1986, p. 41-49. refs

The use of directional solidification, compositional and microstructural control, and anisotropic materials for the development and application of single crystal superalloys are described. It has been known since at least 1946 that elimination or alignment of the grain boundaries to be parallel to the applied stress would remove failure sites. Thermal gradient casting techniques which produce directionally solidified materials are summarized, along with the orientations which can be obtained. Processes which can cause defects such as dendritic freckles to appear in Ni-base superalloys are identified, along with additive elements which can be used to tailure the creep/fatigue strength and oxidation resistance of the alloys. Finally, the metallurgical techniques used to model and control the effects microstructural features have on the mechanical properties of the alloys are outlined. M.S.K.

A87-33269

ADVANCES IN SUPERPLASTIC MATERIALS

NEIL E. PATON (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: Advanced high-temperature alloys: Processing and properties; Proceedings of the Nicholas J. Grant Symposium, Cambridge, MA, June 16-18, 1985 . Metals Park, OH, American Society for Metals, 1986, p. 117-124. refs

The implications of the necessity of having a stable fine grain size in alloys subjected to superplastic forming are discussed, along with recently developed techniques for superplastic forming. Developmental work in powder metallurgy defined methods of obtaining fine grain metals, which are also required to have relatively large grain boundary distortions, a high homologous temperature and a slow strain rate. Superplastic forming is modeled in terms of a combination of diffusional processes consisting of grain exchange mechanisms, and dislocation creep. Techniques used to exploit the modeled superplastic phenomena, including the use of materials with equiaxed grains, for the production of superplastically-formed Al- and Ni-alloys are explored. Progress in achieving commercial-scale superplastic production is assessed, noting that the high strain energies imparted in superplastic forming permit faster production of parts. M.S.K.

A87-33272

TITANIUM ALUMINIDES - FUTURE TURBINE MATERIALS

HARRY A. LIPSITT (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: Advanced high-temperature alloys: Processing and properties; Proceedings of the Nicholas J. Grant Symposium, Cambridge, MA, June 16-18, 1985 . Metals Park, OH, American Society for Metals, 1986, p. 157-164. refs

An ongoing 13 yr old Air Force-University-Industry study of alloys based on intermetallic compounds for aircraft engine components is described. The study has covered basic research on, e.g., the ductile-brittle transition, alloys, compound properties modification, primary processing, obtaining net shapes, and secondary processing. Intermetallic compounds are of interest due to their ordered structures, modulus retention over a wide range of temperature, reduced density and corrosion resistance. Ti_3Al and TiAl compounds have been developed the furthest. The results of recent studies of the mechanical properties and dislocation phenomena in Ti_3Al are summarized, along with tests of ingot melting, casting and forging, sheet rolling, precision casting, superplastic forming, diffusion bonding, isothermal forging and machining of Ti_3Al ingots and engine components. M.S.K.

A87-33647#

SCALING OF IMPACT LOADED CARBON FIBER COMPOSITES

JOHN MORTON (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 819-826. refs

(AIAA PAPER 87-0867)

The application of scaling laws to fiber composite laminates is discussed. Particular emphasis is placed upon the case of impact loading. Scaling difficulties and conflicts are identified and illustrated in an experimental program based upon impacted carbon fiber composite beams. It is shown that the lay-up of laminates is important in assessing the likely validity of scale model tests for such composites. It is also observed that significant size effects may dominate strength modeling. Author

A87-34225

THE EFFECT OF FUEL QUALITY ON THE EMISSION OF POLLUTANTS BY AIRCRAFT GAS-TURBINE ENGINES [VLIIANIE KACHESTVA TOPLIVA NA VYBROS ZAGRIAZNIAIUSHCHIKH VESHCHESTV AVIATSIONNYMI GAZOTURBINNYMI DVIGATELIAMI]

V. P. SVINUKHOV (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Grazhdanskoi Aviatsii, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 2, 1987, p. 34-37. In Russian. refs

A method and equipment for testing aviation fuels for the emission of pollutants are described which make it possible to determine the emission indices for NO(x), C(x)H(y), and CO to within 1.0-1.5 percent and the smoke number to within 12 percent with a confidence level of 0.95. The effect of fuel quality on the emission of pollutants is examined with reference to test results for B-70, RT, and T-6 fuels for idling and maximum thrust conditions. Emission data are also presented for other Soviet-made and foreign fuels, including T-2, TS-1, ATF-K50, T-8, Jet-A1, and Jet-A. Empirical relationships are obtained which make it possible to predict the ecological properties of gas-turbine fuels and to determine the emission characteristics of aircraft engines depending on the grade of fuel used. V.L.

A87-34509#
INGOT METALLURGY ALUMINUM-LITHIUM ALLOYS FOR AIRCRAFT STRUCTURE
J. C. EKVALL and D. J. CHELLMAN (Lockheed-California Co., Burbank) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 203-209) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 255-261. Previously cited in issue 18, p. 2628, Accession no. A86-38822. refs

A87-34668* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN ASSESSMENT OF THE SMALL-CRACK EFFECT FOR 2024-T3 ALUMINUM ALLOY
J. C. NEWMAN, JR., M. H. SWAIN, and E. P. PHILLIPS (NASA, Langley Research Center, Hampton, VA) IN: Small fatigue cracks; Proceedings of the Second International Conference/Workshop, Santa Barbara, CA, Jan. 5-10, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 427-452. refs
Data on small-crack behavior were obtained for a single-edge-notched tensile specimen made of 2024-T3 Al alloy and used to evaluate the capability of a semiempirical crack-growth and closure model to predict the fatigue life of notched specimens. Fatigue tests were conducted under either constant-amplitude loading (with stress ratios of 0.5, 0, -1, and -2) or spectrum loading, using a replication technique to record growth. It was found that small cracks exhibited the 'small-crack' effect in that they grew faster than large cracks when subjected to the same stress intensity factor range. Experimental small-crack growth rates agreed well with the model predictions. For making predictions of fatigue life, an initial surface defect void size of 3 x 12 x 0.4 microns was used in all calculations; predicted fatigue lives agreed well with experimentally determined values obtained in all tests. The crack-closure model indicated that the 'small-crack' effect on fatigue life was greatest in tests involving significant compressive loads. I.S.

A87-34674
THE RELEVANCE OF SHORT CRACK BEHAVIOUR TO THE INTEGRITY OF MAJOR ROTATING AERO ENGINE COMPONENTS
C. HOWLAND, M. A. HICKS, and R. H. JEAL (Rolls-Royce, Ltd., Derby, England) IN: Small fatigue cracks; Proceedings of the Second International Conference/Workshop, Santa Barbara, CA, Jan. 5-10, 1986 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 607-622. refs
Due to very high stresses imposed on major rotating aircraft engine components the usable fatigue life of these components is limited to the short crack regime. The development of an analytical method in which short crack behavior can be used as part of a total life approach to the test disk behavior prediction is discussed. It is shown that such an approach must include a full investigation of the following factors: (1) material microstructure, (2) deformation and failure modes, (3) discontinuity severity and distribution, (4) relationship of the manufacturing process to the real material produced, and (5) relationship of the material behavior modes to a total life concept of material behavior. The development of design/lifting concepts is examined together with possible trends for the future. I.S.

A87-34845
DEVELOPMENT OF FAILURE RESISTANT BISMALEIMIDE/CARBON COMPOSITES
PAUL A. STEINER, JIM M. BROWNE, MICHELE T. BLAIR, and JOHN M. MCKILLEN (Dexter Corp., Hysol Aerospace and Industrial Products Div., Pittsburg, CA) SAMPE Journal (ISSN 0091-1062), vol. 23, Mar.-Apr. 1987, p. 8, 10-14. refs
A new toughened bismaleimide resin, HG9107, has been developed which possesses properties that make it suitable for use in commercial and military aerospace applications. The cure/postcure cycle development, which involves a 6-h postcure at 227 C, is presented together with neat resin characterization and evaluation data. The resin prepreg has good tack, drape, and handleability at a nominal resin content of 30-32 percent. The results of mechanical tests (which included 0-deg short beam shear strength, 0-deg flexure strength and modulus, 0-deg tension strength and modulus, 0-deg compression strength and modulus, +/- 45-deg tensile strength shear modulus, 90-deg flexure, uniform double cantilever beam, and edge delamination strength tests) indicate that the HG9107 prepreg system may be used at 232 C for extended periods of time under dry conditions and at 177 C under high-humidity conditions. I.S.

A87-35024#
GEOMETRIC EFFECTS ON THE COMBUSTION IN SOLID FUEL RAMJETS
R. ZVULONI, A. GANY, and Y. LEVY (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 214-219. refs
The paper summarizes an experimental investigation concerning the geometric and size effects on the combustion in solid fuel ramjets (SFRJs). PMMA (plexiglas) solid fuel was used, and the combustor simulated conditions resulting from flight at sea level and Mach 3. Instantaneous and local fuel regression measurements indicate the following conclusions: the local regression rate is closely related to the local convective heat flux, the nonuniformity of fuel regression rate has a moderating effect on the mass flux dependence of the mean regression rate in extended burn-time tests, the regression pattern is not affected by downstream conditions, and mean regression rate decreases when increasing the port diameter. Nondimensional scales normalized by the fuel length could give generalized expressions for different motors. Author

N87-20178# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Composite Structure Design Dept.
A.T.R. 42 CARBON FIBRE FLAP REPAIR DESIGN AND INSPECTION
GUY HELLARD *In* AGARD The Repair of Aircraft Structures Involving Composite Materials 9 p Oct. 1986
Avail: NTIS HC A11/MF A01
The new commuter aircraft known as ATR.42 developed jointly by Aerospatiale and Aeritalia is the first aircraft of its category to be equipped with carbon fabric flaps. All the airlines which have placed orders for this aircraft are not equipped with the heavy installations required for working on the composite materials. Repair schemes using a simple technology have therefore to be developed. Partial or complete tests have shown that a perfect understanding of the structural ability to withstand the different types of damage was required beforehand. Repair methods using in situ pre-impregnation of dry fabrics have been developed with the relevant method. The mechanical strength of the various repairs and the effects of inadequate damage repairs have been investigated through tests. Author

N87-20268*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMBUSTION RESEARCH IN THE INTERNAL FLUID MECHANICS DIVISION
EDWARD J. MULARZ *In its* NASA-Chinese Aeronautical Establishment (CAE) Symposium p 1-6 1986
Avail: NTIS HC A01/MF A01 CSCL 21B
The goal of this research is to bring computational fluid dynamics to a state of practical application for the aircraft engine industry. The approach is to have a strongly integrated computational and experimental program for all the disciplines associated with the gas turbine and other aeropropulsion systems by advancing the understanding of flow physics, heat transfer, and combustion processes. The computational and experimental research is integrated in the following way: the experiments that are performed provide an empirical data set so that physical models can be formulated to describe the processes that are occurring - for example, turbulence or chemical reaction. These experiments also form a data base for those who are doing code development by

providing experimental data against which the codes can be verified and assesed. Models are generated as closure to some of the numerical codes, and they also provide physical insight for experiments. At the same time, codes which solve the complete Navier-Stokes equations can be used as a kind of numerical experiment from which far more extensive data can be obtained than ever could be obtained experimentally. This could provide physical insight into the complex processes that are taking place. These codes are also exercised against experimental data to assess the accuracy and applicability of models. Author

N87-20269*# Chinese Aeronautical Establishment, Beijing.
NUMERICAL STUDY OF COMBUSTION PROCESSES IN AFTERBURNERS
XIAOQING ZHOU and XIAOCHUN ZHANG (Shenyang Aeroengine Research Inst., China.) *In* NASA- Lewis Research Center NASA-Chinese Aeronautical Establishment (CAE) Symposium p 7-30 1986
Avail: NTIS HC A01/MF A01 CSCL 21B

Mathematical models and numerical methods are presented for computer modeling of aeroengine afterburners. A computer code GEMCHIP is described briefly. The algorithms SIMPLER, for gas flow predictions, and DROPLET, for droplet flow calculations, are incorporated in this code. The block correction technique is adopted to facilitate convergence. The method of handling irregular shapes of combustors and flameholders is described. The predicted results for a low-bypass-ratio turbofan afterburner in the cases of gaseous combustion and multiphase spray combustion are provided and analyzed, and engineering guides for afterburner optimization are presented. Author

N87-20273*# Gas Turbine Research Inst., Jiangyou (China).
COMBUSTION RESEARCH ACTIVITIES AT THE GAS TURBINE RESEARCH INSTITUTE
ZHONGPU SHAO *In* NASA- Lewis Research Center NASA-Chinese Aeronautical Establishment (CAE) Symposium p 89-111 1986
Avail: NTIS HC A01/MF A01 CSCL 21B

The Gas Turbine Research Institute (GTRI) is responsible mainly for basic research in aeronautical propulsion. An annular diffuser for the turbofan augmentor, combustor ignition performance, combustor airflow distribution, fuel injectors, a vaporizer fuel injector, and an airblast atomizer are discussed. Author

N87-20387*# Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
ADVANCED COMPOSITE COMBUSTOR STRUCTURAL CONCEPTS PROGRAM Final Report
M. A. SATTAR and R. P. LOHMANN Dec. 1984 118 p
(Contract NAS3-23284)
(NASA-CR-174733; NAS 1.26:174733; PWA-5890-24) Avail: NTIS HC A06/MF A01 CSCL 11D

An analytical study was conducted to assess the feasibility of and benefits derived from the use of high temperature composite materials in aircraft turbine engine combustor liners. The study included a survey and screening of the properties of three candidate composite materials including tungsten reinforced superalloys, carbon-carbon and silicon carbide (SiC) fibers reinforcing a ceramic matrix of lithium aluminosilicate (LAS). The SiC-LAS material was selected as offering the greatest near term potential primarily on the basis of high temperature capability. A limited experimental investigation was conducted to quantify some of the more critical mechanical properties of the SiC-LAS composite having a multidirection 0/45/-45/90 deg fiber orientation favored for the combustor linear application. Rigorous cyclic thermal tests demonstrated that SiC-LAS was extremely resistant to the thermal fatigue mechanisms that usually limit the life of metallic combustor liners. A thermal design study led to the definition of a composite liner concept that incorporated film cooled SiC-LAS shingles mounted on a Hastelloy X shell. With coolant fluxes consistent with the most advanced metallic liner technology, the calculated hot surface temperatures of the shingles were within the apparent near term capability of the material. Structural analyses indicated that the stresses in the composite panels were low, primarily because of the low coefficient of expansion of the material and it was concluded that the dominant failure mode of the liner would be an as yet unidentified deterioration of the composite from prolonged exposure to high temperature. An economic study, based on a medium thrust size commercial aircraft engine, indicated that the SiC-LAS combustor liner would weigh 22.8N (11.27 lb) less and cost less to manufacture than advanced metallic liner concepts intended for use in the late 1980's. Author

N87-20406*# Lockheed-California Co., Burbank.
DEVELOPMENT OF POWDER METALLURGY 2XXX SERIES AL ALLOY PLATE AND SHEET MATERIALS FOR HIGH TEMPERATURE AIRCRAFT STRUCTURAL APPLICATIONS, FY 1983/1984 Final Technical Report, 30 Sep. 1982 - 31 Aug. 1984
D. J. CHELLMAN Apr. 1985 78 p
(Contract NAS1-16048)
(NASA-CR-172521; NAS 1.26:172521; LR-30775) Avail: NTIS HC A05/MF A01 CSCL 11F

The objective of this investigation is to fabricate and evaluate PM 2124 Al alloy plate and sheet materials according to NASA program goals for damage tolerance and fatigue resistance. Previous research has indicated the outstanding strength-toughness relationship available with PM 2124 Al-Zr modified alloy compositions in extruded product forms. The range of processing conditions was explored in the fabrication of plate and sheet gage materials, as well as the resultant mechanical and metallurgical properties. The PM composition based on Al-3.70 Cu-1.85 Mg-0.20 Mn with 0.60 wt. pct. Zr was selected. Flat rolled material consisting of 0.250 in. thick plate was fabricated using selected thermal mechanical treatments (TMT). The schedule of TMT operations was designed to yield the extreme conditions of grain structure normally encountered in the fabrication of flat rolled products, specifically recrystallized and unrecrystallized. The PM Al alloy plate and sheet materials exhibited improved strength properties at thin gages compared to IM Al alloys, as a consequence of their enhanced ability to inhibit recrystallization and grain growth. In addition, the PM 2124 Al alloys offer much better combinations of strength and toughnessover equivalent IM Al. The alloy microstructures were examined by optical metallographic texture techniques in order to establish the metallurgical basis for these significant property improvements. Author

N87-21135# IIT Research Inst., Bartlesville, Okla. National Inst. for Petroleum and Energy Research.
TECHNIQUES TO DETERMINE PARTICULATES IN LIQUID FUELS Status Report
O. K. BHAN and D. W. BRINKMAN Sep. 1986 23 p Prepared for DOE and Naval Air Propulsion Center, Trenton, N.J.
(Contract DE-FC22-83FE-60149)
(DE87-002028; NIPER-202) Avail: NTIS HC A02/MF A01

The objective of the current study is to search for test methods and techniques which can be used for fuel contaminant detection possibly under field conditions. In this report, several techniques have been identified which hold promise for jet fuel contaminant detection under field conditions. Instrumentation currently available for the aforementioned application are discussed and recommendations are made. Out of the ten techniques described in this review, four techniques (light scattering, ultrasonic attenuation, laser light obscuration, and laser holography) seem to hold promise for detecting particulates, and to some extent water, in jet fuels. For most of the methods, off-the-shelf instruments are available. Almost all of the equipment available requires ac 110/220 V power; however, some of the instruments can be modified for dc voltage use. In addition, some of the instruments can be miniaturized for field use. DOE

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ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A87-31491
INTEGRATING SPEECH TECHNOLOGY TO MEET CREW STATION DESIGN REQUIREMENTS
CAROL A. SIMPSON (Psycho-Linguistic Research Associates, Menlo Park, CA), JOHN C. RUTH (McDonnell Douglas Electronics Co., Saint Charles, MO), and CAROLYN A. MOORE (VERAC, Inc., San Diego, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 324-329. refs

The last two years have seen improvements in speech generation and speech recognition technology that make speech I/O for crew station controls and displays viable for operational systems. These improvements include increased robustness of algorithm performance in high levels of background noise, increased vocabulary size, improved performance in the connected speech mode, and less speaker dependence. This improved capability makes possible far more sophisticated user interface design than was possible with earlier technology. Engineering, linguistic, and human factors design issues are discussed in the context of current voice I/O technology performance. Author

A87-31500#
TESTABILITY MANAGEMENT FOR DIGITAL AVIONICS
WILLIAM L. KEINER (U.S. Navy, Surface Weapons Center, Dahlgren, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 397-401.

MIL-STD-2165, 'Testability Program for Electronic Systems and Equipments' was issued on Jan. 26, 1985. This standard may be applied to all electronics developments within the Department of Defense. This paper discusses the role of the new military standard as a management tool for the development of testable avionics systems and equipments. A framework is presented for managing testability requirements trade-offs, design tradeoffs and testability evaluations. Author

A87-31501#
MEASURING INSTABILITY DURING AVIONIC DESIGN
JAMES C. BUSSERT (U.S. Navy, Ocean Systems Center, San Diego, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 407-409.

The promulgation of the MILSTD 2165 on Testability for Electronic Equipments in 1985, suddenly mandated the demonstration of testability, just as maintainability, reliability and other institutionalized 'ilities' have been for years. There are several Testability Figure of Merit (TFOM) tools available but avionics engineers and program managers (PM) need to know which ones are applicable to digital avionics, and then which one is optimum for their application. The author has utilized two TFOM checklists, two CAD software TFOMs, and two logic model TFOMs on a VLSI avionic module. The advantages and limitations of each are pointed out on a modern complex digital aircraft unit under test. Author

A87-31506
PASSIVE FIBER-OPTIC COHERENCE MULTIPLEXING FOR AIRCRAFT SENSORS
WALTER L. GLOMB, JR. (United Technologies Research Center, East Hartford, CT) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 437-442. refs

A fiber-optic transducer which employs coherence multiplexing for optical transmission of binary encoded data via a singlemode optical fiber to a coherent optical receiver is described. An encoder is used to read the position of an optical coded plate and switches in a parallel binary format, delay each channel with respect to the others using fiberoptic delay lines and combine them into a single fiber. A phase-carrier, coherent detection scheme with a limited coherence laser is used to multiple the information on the single fiber. This multiplexing technique allows up to 100 binary signals at 10 kbps to be transmitted simultaneously over a single fiber, and then separated by coherent detection using relatively short delay lines compared to time division multiplex systems. Because a CW laser is the source of light, no pulsed electronics are needed. Furthermore, heterodyne detection can be used to enhance the signal-to-noise ratio. Laboratory results from a two channel experiment are presented and general application to passive coherent binary amplitude-shift-keyed data networks is discussed. Author

A87-31526
ADJUSTMENT DIAGNOSTICS AND FAULT ISOLATION FOR CALIBRATION TEST OF JET ENGINE CONTROLS
CHARLES R. HALL, JR. and DAVID C. THOMAN (Allied-Signal, Inc., Bendix Energy Controls Div., South Bend, IN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 591-595.

Concepts employed in the design of automatic test systems for large hydromechanical engine controls are described. Such test systems not only eliminate most of the physical effort required for manual test, but more importantly, these systems are being programmed to make nearly all decisions required for test, calibration and fault isolation of engine controls. The expanding level of intelligence being built into advanced test systems has dramatically reduced the training and skill level required for test personnel. Adjustment diagnostic software is now directing and supervising the total engine control calibration process at some test facilities. Software based upon expert system technology has provided the capability to capture knowledge and experience of human experts to perform selected tasks. These include, for example, fault isolation of the engine control and the test station hardware. Author

A87-31534
APPLICATIONS OF VLSI IN ELECTRONIC TURBINE ENGINE CONTROLS
GREGORY P. GOODZEY (Allied-Signal, Inc., Bendix Energy Controls Div., South Bend, IN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 641-646.

In electronic controls for turbine engines, VLSI has several benefits to system designers in meeting size and weight constraints. Along with reviewing these advantages, this paper describes the selection process and criteria, the design process, and test of VLSI circuits for engine control applications using a standard cell library and a CAD development system similar to commercially available systems. The author emphasizes the development of standard, written procedures to ensure that designs proceed in a regular and predictable manner, from system partitioning and device selection to chip testing. Specific cases of problems encountered in chip design and the solutions found are also discussed. Author

A87-31539

PROBLEMS WITH FAILURE MODES AND EFFECTS ANALYSIS FOR DIGITAL AVIONICS

HERBERT HECHT (SoHar, Inc., Los Angeles, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 695-700.

The provisions of the MIL-STD-1629A standard for Failure Modes and Effects Analysis (FMEA) are discussed with respect to their applicability to digital avionics equipment, and problem areas are highlighted. It is noted that current practices usually circumvent rather than correct deficiencies, and that they introduce duplication and uncertainty into the application of FMEA-related information in the design of digital equipment. An approach in which an individual FMEA is restricted to one hierarchical level, and in which a built-in feedback mechanism identifies and corrects its own deficiencies by identifying FMEA problem areas as part of the normal reporting system, is proposed. R.R.

A87-31676

THE RAPID EXPANSION OF A SUPERSONIC TURBULENT FLOW - ROLE OF BULK DILATATION

J. P. DUSSAUGE and J. GAVIGLIO (Aix-Marseille II, Universite, Marseille, France) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 174, Jan. 1987, p. 81-112. Research supported by the Universite d'Aix-Marseille II and ONERA. refs

The rapid expansion of a turbulent boundary layer in supersonic flow is studied analytically and experimentally. Emphasis is placed on the effect of bulk dilatation on turbulent fluctuations. The hypotheses made in the analysis are similar to those in the rapid distortion theory and are used to simplify second-order closures. By assuming that the fluctuating velocity is solenoidal an extension of classical subsonic models is proposed. A new variable is defined, which takes into account the mean density variations, and behaves like the Reynolds stress tensor in subsonic flows with weak inhomogeneities and a weak dissipation rate. The results of the analysis are compared with turbulence measurements performed in a supersonic boundary layer subjected to an expansion fan. The proposed approximations describe correctly the evolution of turbulence intensities: bulk dilatation contributes predominantly to the Reynolds stress evolution. The boundary layer is 'relaminarized' by the expansion. Downstream of the latter, the layer returns to equilibrium. Measurements show that the turbulence decays slowly in the outer layer and increases rapidly in the inner layer. Author

A87-31722

RHEOLOGICAL CHARACTERISTICS OF PARTS OF MR MATERIAL USED IN GAS TURBINE ENGINES [REOLOGICHESKIE KHARAKTERISTIKI IZDELII IZ MATERIALA MR, PRIMENIAEMYKH V GTD]

A. I. BELOUSOV and A. A. TROINIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 16-20. In Russian. refs

A study is made of the rheological characteristics of the vibration-damping components of gas turbine engines made of MR material, a nonwoven porous material made of cold-pressed spiral wire. During the manufacture of damping elements, the diameter of the spiral increases by 1-3 percent and its stretch pitch decreases by 2-3 percent due to creep. The pressing of MR damping elements is accompanied by stress relaxation and creep (up to 10 percent); cold-pressed specimens partially recover their geometrical dimensions up to 2-4 percent. The linear dimensions of statically stabilized specimens increase in the direction of the pressing force by 1-2 percent. The rheological characteristics of the damping elements during operation under static and dynamic loading and under conditions of contact friction are examined. V.L.

A87-31727

STRAIN DETERMINATION DURING THE EXPLOSIVE EXPANSION OF PIPES [OPREDELENIE DEFORMATSII PRI VZRYVNOI RAZDACHE TRUB]

IU. P. KATAEV, E. F. VIALKOV, and V. M. BELONOG Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 39-42. In Russian.

The manufacture of aircraft includes processes whereby pipes are expanded by a dynamic impulse pressure field. Here, stress and strain distributions associated with such processes are investigated theoretically with a view to process optimization. The analysis is carried out using a rectangular finite element, with the displacement function expressions supplemented by additional variables to improve the approximation of displacements between the nodes and to reduce the number of finite-element subdivisions. V.L.

A87-31730

GEOMETRICALLY NONLINEAR THEORY FOR THIN-WALLED RODS [GEOMETRICHESKI NELINEINAIA TEORIIA TONKOSTENNYKH STERZHNEI]

A. S. SAFONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 51-54. In Russian.

Reference is made to an earlier study (Pavlov and Safonov, 1983) in which a method was proposed for calculating thin-walled reinforced aircraft structures on the basis of a deformation scheme allowing for finite displacements of the structure axis. In the present study, this approach is further developed to allow the use of nonlinear deformation relationships for the main supporting elements of a structure. In this case, the resolvent equations of the method become nonlinear, providing for more rigorous determinations of the stress-strain state of thin-walled structures of the type commonly used in aircraft. V.L.

A87-31732

THE EFFECT OF LOWER AND UPPER OVERLAPS ON THE EFFICIENCY OF CENTRIPETAL RADIAL-FLOW AIR MICROTURBINES WITH PARTIAL ADMISSION [VLIIANIE VELICHINY VERKHNEI I NIZHNEI PEREKRYSH NA EKONOMICHNOST' RADIAL'NYKH TSENTROSTREMITEL'NYKH VOZDUSHNYKH MIKTOTURBIN S PARTSIAL'NYM PODVODOM]

N. T. TIKHONOV and A. N. TIKHONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 59-63. In Russian.

The effect of the lower and upper overlaps on the efficiency of partial centripetal microturbines is investigated experimentally for upper overlaps of +1.0, +0.8, +0.6, +0.4, +0.2, 0.0, -0.2, -0.4, and -0.6 mm and lower overlaps from 1.5 to 0.1 mm (at 0.1-mm intervals). It is found that the optimal values of the lower and upper overlaps depend on the feed and expansion ratios and have a noticeable effect on the efficiency of a turbine. Experimental results are presented in graphic form. V.L.

A87-31734

MINIMIZING THE VIBRATION AMPLITUDE OF A SYMMETRICAL ROTOR AT A SPECIFIED RESONANCE FREQUENCY [MINIMIZATSIIA AMPLITUDY KOLEBANII SIMMETRICHNOGO ROTORA PRI ZADANNOI REZONANSNOI CHASTOTE]

D. E. CHEGODAEV, L. M. RUDMAN, and S. M. SHTEINBERG Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 67-70. In Russian.

The problem of minimizing the vibration amplitude for a specified resonance frequency is posed and solved for a model of a symmetrical single-mass flexible rotor on viscoelastic supports. The optimal parameters of the model are compared with the parameters obtained by solving the problem of optimal damping. It is shown that the decrease in amplitude resulting from resonance minimization at a given resonance frequency is small in comparison with that resulting from optimal damping. V.L.

A87-31735
CALCULATION OF THE PARAMETERS OF A HARDENING BURNISHING TREATMENT [RASCHET PARAMETROV PROTSESSA UPROCHNIAIUSHCHEGO DORNOVANIIA]
V. V. SHCHERBATYKH, A. I. IARKOVETS, and IU. D. LYSENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 70-76. In Russian. refs

The evolution of the stress-strain state of a material near a hole hardened by burnishing is analyzed with allowance for the burnisher geometry and feed rate. Analytical expressions are obtained which make it possible to design a burnishing treatment in accordance with the specified residual stress-strain state in the area of a hole. They also make it possible to determine optimum tool geometry and feed rate and to select the required drive type accordingly. V.L.

A87-31739
DETERMINATION OF PRESSURE LOSSES IN THE COMPRESSOR OF A GAS TURBINE ENGINE IN THE AUTOROTATION MODE [K VOPROSU OPREDELENIIA POTER' DAVLENIIA V KOMPRESSORE GTD NA REZHIMAKH AVTOROTATSII]
V. I. DAINEKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 84-86. In Russian. refs

An analytical expression for calculating pressure losses in the compressor of a gas turbine engine is proposed which allows for both the rotor speed and air parameters at the compressor inlet, the flow rate and the rotation speed being independent variables. The independence of these parameters makes it possible to determine pressure losses in the compressor not only during steady autorotation but also during the transition to autorotation and during rotation by a starter. The method is illustrated by an example. V.L.

A87-31743
CALCULATION OF EVAPORATION UNDER CONDITIONS OF STRONG VAPOR OUTFLOW [RASCHET ISPARENIIA V USLOVIIAKH SIL'NOGO OTTOKA PARA]
G. P. POTAPOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 95, 96. In Russian.

An analytical expression is obtained for calculating the evaporation of a liquid in the case where the evaporation rate is much less than the rate of vapor outflow off the liquid surface. Such conditions may exist, for example, in the duct of an engine where the mean free path of molecules is 0.0001 cm and the break-away velocity of the evaporating molecules is 1-100 cm/s. It is shown that the maximum evaporation rate is largely determined by the nature of the liquid and its surface temperature. V.L.

A87-31994
DERIVATION OF A FUNDAMENTAL SOLUTION TO THE EQUATION OF AEROELASTIC VIBRATIONS OF A PANEL [POBUDOVA FUNDAMENTAL'NOGO ROZV'IAZKU RIVNIANNIA AEROPRUZHNIKH KOLIVAN' PANELI]
I. T. SELEZOV and V. G. MATVEEV (AN USSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR) Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A Fiziko-Matematichni ta Tekhnichni Nauki (ISSN 0002-3531), Nov. 1986, p. 35-39. In Ukrainian. refs

A fundamental solution is derived in terms of convolution algebra for an equation describing the aeroelastic vibrations of a panel using an exact formulation. In accordance with the approach used here, the initial equation is reduced to a second-order Volterra equation which is then solved using the method of successive approximations. The convergence of the resulting series is demonstrated. V.L.

A87-32022
THE ANNULAR APERTURE ANTENNA WITH A HEMISPHERICAL CENTER CONDUCTOR EXTENSION
ROBERT D. NEVELS (Texas A & M University, College Station) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. AP-35, Jan. 1987, p. 41-45. refs

An annular aperture antenna mounted on an infinite ground plane and containing a hemispherical center conductor extension above the ground plane is investigated. A Green's function for the region above the ground plane is derived so as to be compatible with numerical solution techniques. A magnetic field integral equation is obtained in terms of the unknown tangential aperture electric field and is solved by the method of moments. A comparison between flush mounted and hemispherically extended annular aperture antennas is presented for the tangential aperture electric field, the coaxial line apparent input admittance, and the far radiated field. Author

A87-32107
SELF-PROTECTION CM - PRESENT AND FUTURE
R. E. MARINACCIO and D. B. BERGSMA (Westinghouse Defense and Electronics Center, Baltimore, MD) Microwave Journal (ISSN 0026-2997), vol. 30, Feb. 1987, p. 97, 98, 100 (8 ff.).

The requirements of self-protection countermeasure systems are discussed as well as ECM techniques, system architectures, installations, and future trends. Power management methods and utility are considered in terms of threat sorting and identification, time gating control, frequency set-on, polarization control, and direction control. Self-protection ECM systems are installed on tactical aircraft in one of the following configurations: (1) external (pods), (2) conformal (or blister mount), or (3) internal. Examples of each of these configurations are given. K.K.

A87-32202
NDT METHODS FOR BONDED ASSEMBLIES
HAROLD BERGER (Industrial Quality, Inc., Gaithersburg, MD) Society of Manufacturing Engineers, Conference on Composites in Manufacturing, 5th, Los Angeles, CA, Jan. 13-16, 1986, Paper. 10 p. refs
(Contract F33615-82-C-5054)

The capabilities of the IR thermography and holographic interferometry NDT equipment used at the McClellan AFB for inspecting honeycomb aircraft panels were compared. Disbond defects in the panels, which had Al and fiber glass cover sheets and Al and phenolic cores, were simulated by installing inserts. Baseline data on the defects were obtained with ultrasonic and X-ray scans. Noncontact pulsed thermographic scans proved viable for revealing excess adhesive in fiberglass skin panels, and worked best with materials which were poor conductors of heat. Holographic interferometry was effective for detecting manufacturing variations such as skin thickness changes, core shear ties, and, too, excess adhesive. M.S.K.

A87-32207
THE 'MOEN' REAL TIME HEATING SYSTEM FOR CURING AND FORMING 350 DEG RESIN AND 700 DEG THERMOPLASTIC COMPOSITES
ROBERT W. AUKERMAN and STANLEY D. LEWIS (Heat Transfer Technologies, Inc., Encino, CA) Society of Manufacturing Engineers, Conference on Composites in Manufacturing, 5th, Los Angeles, CA, Jan. 13-16, 1986, Paper. 13 p.

Features and performance capabilities of the Moen Heating system (MHS) for providing fast, uniform heating/cooling for airframe components are explored. Shop air is sucked through a heating coil and then a delivery system which is conformal or integral to the part or mold. Tailored-size perforations permit the hot air to impinge directly on the part or tool as desired. The high velocity of the air flow reduces the required size of the system, while thermocouples in the delivery system permit real-time control of the part temperature and insulating the part from the ambient conditions. A cryogenic loop can be incorporated in the system to extend the temperature range to -300 to +2000 F. M.S.K.

A87-32419

EXPERIMENTAL MOBILE SATELLITE SYSTEM (EMSS) USING ETS-V

YOSHIHIRO HASE, SHINGO OHMORI, and KATSUHIKO KOSAKA (Ministry of Posts and Telecommunications, Radio Research Laboratories, Koganei, Japan) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 . Tokyo, AGNE Publishing, Inc., 1986, p. 1069-1074.

Radio Research Laboratory has been developing a mobile satellite communication system. The satellite to be used in this system is called Engineering Test Satellite-five (ETS-V) and is scheduled to be launched in the summer of 1987. The main purpose of the system is to perform experiments on maritime and aeronautical satellite communications. Experiments on land mobile communications are also to be carried out. L-band frequencies for links between the satellite and mobile earth stations and C-band frequencies for the feeder link between the satellite and a coastal/aeronautical earth station are used in the system. The service area extends to the North Pacific Ocean including Japan and the West Pacific Ocean. In the system, various digital communication experiments are to be carried out through SCPC, TDM/TDMA, and SS channels.This paper describes items of experiments and facilities of the system. This system is an integrated mobile satellite communication system for maritime, aeronautical, and land mobile services, and may be the first of this kind in the world except military systems, though it is not an operational system. Author

A87-32580

SIMULATION OF OIL CIRCUITS IN VSCF ELECTRICAL POWER SYSTEMS

MICHAEL L. BUMBAUGH and DAVID P. HOSEY (Westinghouse Electric Corp., Electrical Systems Div., Lima, OH) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 13 p. refs
(SAE PAPER 861623)

Simulation techniques have been developed to determine oil circuit flow rate, pressure, and temperature throughout a Variable Speed Constant Frequency (VSCF) electrical power system. This data can be used to indicate if a VSCF system is adequately cooled and lubricated throughout an aircraft flight envelope. A combination of spray-oil and conduction cooling is an effective means of dissipating heat, and provides for lubrication within the same oil circuit. Cooling effectiveness increases with oil flow rate, but a higher flow rate also increases pumping power consumption and lowers VSCF generator efficiency. Oil circuit simulation can be used to optimize flow rate; the result is more efficient VSCF systems, shortened design times, and reduced product development test time. Author

A87-32597

HYDRAULIC COMPONENTS FOR HIGH PRESSURE HYDRAULIC SYSTEMS

JOHN HALAT (Vickers, Inc., Jackson, MS) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 10 p.
(SAE PAPER 861677)

Design considerations that 8000 psi and nonflammable fluids have upon aircraft hydraulic pumps and motors are presented. The influence of one nonflammable fluid, chlorotrifluoroethylene (CTFE) is discussed. The employment of variable displacement pressure scheduled pumps and variable displacement motors is shown to provide significant savings in power and heat generation. The paper includes a summary of the high pressure and nonflammable fluid operating experience on both pumps and motors. A review of a unified method in presenting test data at high pressure is presented. The paper concludes with update summaries of the Wright Patterson Air Force Base contract for three 40 gpm, 8000 psi CTFE pumps as well as the test time for a Model PV3-047 pump operating at 8000 psi on the Navy Lightweight Hydraulic System test. Author

A87-32605

MICROPROCESSORS IN JET ENGINE BALANCING MACHINES

DOUGLAS G. STADELBAUER (Schenck Trebel Corp., Deer Park, NY) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 8 p.
(SAE PAPER 861704)

This article discusses the use of microprocessor controlled unbalance measuring systems for dynamic balancing of jet engine rotors. Various signal processing modes and features are described, together with their particular application to the indication of unbalance in turbine and compressor rotors. Author

A87-32614

ANALYTICAL REDUNDANCY TECHNOLOGY FOR ENGINE RELIABILITY IMPROVEMENT

HAROLD BROWN (General Electric Co., Cincinnati, OH) and RUSSELL W. VIZZINI (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 13 p.
(Contract N00140-83-C-9046)
(SAE PAPER 861725)

The ARTERI concept for achieving engine control system fault detection, isolation, and accommodation is described. It uses analytical redundancy to improve system reliability in conjunction with or instead of hardware redundancy and can also be used as a diagnostic tool. The key elements of ARTERI include a real-time component level engine model for synthesizing sensor outputs, a component tracking filter for updating the model to match the actual engine, and a failure detection filter for detecting and isolating hard and soft system falts. Faults are accommodated by the use of model outputs in place of failed sensors and alternative operating schedules for minimizing performance degradation due to failed actuators. The design concept of each element is described and expected operating characteristics are discussed. Author

A87-32917

EFFECT OF GEOMETRIC ELASTIC NON-LINEARITIES ON THE IMPACT RESPONSE OF FLEXIBLE MULTI-BODY SYSTEMS

E. M. BAKR and A. A. SHABANA (Illinois, University, Chicago) *Journal of Sound and Vibration* (ISSN 0022-460X), vol. 112, Feb. 8, 1987, p. 415-432. refs

The intermittent motion behavior of large scale geometrically nonlinear flexible multibody systems due to impact loading is investigated. Impacts and the associated impulsive forces are incorporated into the dynamic formulation by using a generalized momentum balance. The solution of the momentum equation provides the jump discontinuities in the system velocities and reaction forces. Flexible components in the system are discretized by using the finite element method. Because of the large rotations of the system components, a set of reference co-ordinates are employed to describe the motion of a selected body reference. The rigid body modes of the finite element shape functions are eliminated by using a set of reference conditions and accordingly a unique displacement field is defined. In order to account for the inertia and elastic nonlinearities which are, respectively, the results of the large rotations and finite deformations, the system inertia and stiffness characteristics have to be iteratively updated. Two numerical examples of different nature are presented. The first example is a high speed slider crank mechanism with a flexible connecting rod. In the second example, however, the dynamic response of a flexible multibody aircraft during the touch down impact is predicted. Author

A87-33173

CURRENT CAPABILITIES OF NDT - A SERVICE OPERATOR'S VIEW

I. F. FAIRHEAD (RAF, Trade Management Training School, Scampton, England) Aerospace (UK) (ISSN 0305-0831), vol. 14, Feb. 1987, p. 17-20.

An account is given of the range of NDT requirements encountered by RAF service operators in virtue of the wide range of aircraft types and ages in operation; about 160 new NDT

techniques are developed every year. Current aircraft primary structures are metallic irrespective of age, though varying greatly in cross-section dimensions and fastening methods. The dispersed nature of the maintenance, and the safety requirements stipulated, result in heavy RAF reliance on battery-powered NDT equipment. The RAF has conducted statistical studies using a Monte Carlo computer model to simulate the development of a typical fatigue crack in a large structure and its periodic inspection by NDT methods. A major problem with NDT is that small, tight fatigue cracks are difficult to detect. O.C.

A87-33181
TITANIUM ALLOY SPRINGS
S. R. SEAGLE (RMI Co., Niles, OH), R. BAJORAITIS (Boeing Commercial Airplane Co., Seattle, WA), and C. F. PEPKA (Renton Coil Spring Co., WA) (Institute of Metals, Conference on Designing with Titanium, University of Bristol, England, July 7-9, 1986) Materials Science and Technology (ISSN 0267-0836), vol. 3, Feb. 1987, p. 97-100. refs

Beta-type titanium alloys offer a unique combination of properties for springs. Their high strength, low elastic modulus, low density, and good corrosion resistance result in springs designed to be both smaller and lighter and more corrosion-resistant than springs made of other materials. Design considerations, along with mechanical and fatigue properties, are discussed f or a Ti-3Al-8V-6Cr-4Mo-4Zr alloy. Examples of applications are included. Author

A87-33250
AIRCRAFT PRODUCTION TECHNOLOGY
DOUGLAS FAVEL HORNE Cambridge and New York, Cambridge University Press, 1986, 219 p. refs

Current aircraft-production techniques are surveyed and illustrated with extensive drawings, diagrams, and photographs. The history of the British aircraft industry is reviewed, and individual chapters are devoted to Al alloys; steels, Ni alloys, and Ti alloys; metal-cutting machinery; welding and brazing; surface treatments; protective treatments; sheet-metal working; nonmetallic materials; assembly; inspection and testing; and production estimates, production planning, and CAD/CAM. T.K.

A87-33380
RELATION BETWEEN THE PARAMETERS OF A DAMPED STRUCTURE AND THOSE OF AN UNDAMPED STRUCTURE. I - LOW STRUCTURAL DAMPING. A PROPOSAL FOR AN IDENTIFICATION FUNCTION [BEZIEHUNG ZWISCHEN DEN KENNGROESSEN EINER GEDAEMPFTEN UND DENEN DER ZUGEHOERIGEN UNGEDAEMPFTEN STRUKTUR. I - KLEINE STRUKTURELLE DAEMPFUNGEN. VORSCHLAG EINER INDIKATORFUNKTION]
HELMUT WITTMEYER Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Nov.-Dec. 1986, p. 418-425. In German. refs

The low structural damping associated with aircraft construction is examined and procedures for calculating the parameters of an undamped system are described. The associated real mode of the undamped structure corresponding to a given complex natural mode of a vibrating structure with weak structural damping is determined using a mass matrix. The relation between the natural mode and the natural angular frequency is studied. An indicator function is derived and compared with that of Breitbach (1974); the advantages of the derived indicator function are discussed. I.F.

A87-33562*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FURTHER GENERALIZATION OF AN EQUIVALENT PLATE REPRESENTATION FOR AIRCRAFT STRUCTURAL ANALYSIS
GARY L. GILES (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 93-103. refs
(AIAA PAPER 87-0721)

Recent developments from a continuing effort to provide an equivalent plate representation for aircraft structural analysis are described. Previous work provided an equivalent plate analysis formulation that is capable of modeling aircraft wing structures with a general planform such as cranked wing boxes. However, the modeling is restricted to representing wing boxes having symmetric cross sections. Further developments, which are described in this paper, allow modeling of wing cross section having asymmetries that can arise from airfoil camber or from thicknesses being different in the upper and lower cover skins. An implementation of thermal loadings, which are described as temperature distributions over the planform of the cover skins, has been included. Spring supports have been added to provide for a more general set of boundary conditions. Numerical results are presented to assess the effect of wing camber on the static and dynamic response of an example wing structure under pressure and thermal loading. These results are compared with results from a finite element analysis program to indicate how well a cambered wing box can be represented with an equivalent plate formulation. Author

A87-33566#
ANALYTICAL AND EXPERIMENTAL STUDIES ON THE BUCKLING OF LAMINATED THIN-WALLED STRUCTURES
CHENG WANG, THEODORE H. H. PIAN, JOHN DUGUNDJI, and PAUL A. LAGACE (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 135-140. refs
(Contract F33615-83-K-5016)
(AIAA PAPER 87-0727)

The buckling and postbuckling behavior of some thin-walled structures made of laminated composite materials are studied by finite element analyses and by experimental investigations. The predicted buckling loads and modes agree reasonably well with experiments. The failure loads however cannot be estimated from the present post-buckling solutions which are based on the classical lamination theory. Author

A87-33572*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
POSTBUCKLING AND FAILURE CHARACTERISTICS OF STIFFENED GRAPHITE-EPOXY SHEAR WEBS
MARSHALL ROUSE (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 181-193. refs
(Contract NAS1-15949)
(AIAA PAPER 87-0733)

Results are presented from an experimental study of the postbuckling response and failure characteristics of flat, stiffened graphite-epoxy shear webs in which attention was given to the influence of stiffener attachment concepts, circular holes, and low speed impact damage on postbuckling performance. The laminate specimens chosen for testing are typical of those employed for transport aircraft primary structures. Test results show that low speed impact damage midway between stiffeners initiated specimen failure; the strength of an impact-damaged specimen was less than that of the corresponding control specimen. O.C.

A87-33575#
STOCHASTIC APPROACH FOR PREDICTING FUNCTIONAL IMPAIRMENT OF METALLIC AIRFRAMES
J. N. YANG (George Washington University, Washington, DC), S. D. MANNING (General Dynamics Corp., Fort Worth, TX), J. L. RUDD, M. E. ARTLEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and J. W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 215-223. refs
(Contract F33615-84-C-3208)
(AIAA PAPER 87-0752)
An existing method of durability analysis for evaluating excessive cracking in metallic airframes has been extended to cover functional impairment due to fuel leakage/ligament breakage. The initial fatigue quality of fastener holes is represented by an equivalent initial flaw size distribution (EIFSD). Once the EIFSD has been defined, a two-segment deterministic-stochastic crack growth approach is used to grow the EIFSD forward to predict the probability of crack exceedance at any service time. Author

A87-33600*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A METHOD OF PREDICTING THE ENERGY-ABSORPTION CAPABILITY OF COMPOSITE SUBFLOOR BEAMS
GARY L. FARLEY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 428-437. refs
(AIAA PAPER 87-0800)
A simple method of predicting the energy-absorption capability of composite subfloor beam structure has been developed. The method is based upon the weighted sum of the energy-absorption capability of constituent elements of a subfloor beam. An empirical data base of energy absorption results from circular and square cross section tube specimens were used in the prediction capability. The procedure is applicable to a wide range of subfloor beam structure. The procedure was demonstrated on three subfloor beam concepts. Agreement between test and prediction was within seven percent for all three cases. Author

A87-33648*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
STRUCTURAL TAILORING OF ADVANCED TURBOPROPS
K. W. BROWN, P. R. HARVEY (Pratt and Whitney, East Hartford, CT), and C. C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 827-837. refs
(AIAA PAPER 87-0753)
A computer program has been developed for the performance of numerical optimizations of highly swept propfan blades by minimizing an objective function that is defined either as direct operating cost or the aeroelastic difference between a blade and its scaled model. Three component analysis categories are employed: an optimization algorithm, approximate analysis procedures for objective function and constraint evaluation, and refined analysis procedures for optimum design validation. The analyses conducted by the program encompass aerodynamic efficiency evaluation, finite element stress and vibration analysis, acoustics, flutter, and forced response life prediction. O.C.

A87-33663#
THE EFFECT OF GYROSCOPIC FORCES ON DYNAMIC STABILITY AND RESPONSE OF SPINNING TAPERED BLADES
T. N. SHIAU (National Cheng Kung University, Tainan, Republic of China) and JONG-SHING TONG IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 76-83. refs
(AIAA PAPER 87-0737)
The dynamic stability and response of a spinning tapered blade under the effect of gyroscopic forces induced by precession of the rotor spin axis is investigated. The stability of the system is studied using a perturbation method and the Floquet theory, and the results are shown to be in agreement with both methods. A technique based on the Floquet theory and periodicity condition is presented to find the initial condition for steady state periodic response by only one period of integration. The technique can substantially reduce the computing time for finding a periodic response. The results show that the blade tip displacement is monotonically dependent on the gyroscopic effect. Author

A87-33675#
EXPERIMENTAL INVESTIGATION OF STRUCTURAL AUTOPARAMETRIC INTERACTION UNDER RANDOM EXCITATION
R. A. IBRAHIM (Texas Tech University, Lubbock) and D. G. SULLIVAN IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A . New York, American Institute of Aeronautics and Astronautics, 1987, p. 217-225. refs
(Contract AF-AFOSR-85-0008)
(AIAA PAPER 87-0779)
The paper presents the results of an experimental investigation of random excitation of a nonlinear two-degree-of-freedom structural model. The model normal mode frequencies are adjusted to have the ratio of 2 to 1. This ratio meets the condition of internal resonance of the analytical model. When the first normal mode is externally excited by a band limited random excitation, the system mean square response is found to be linearly proportional to the excitation spectral density up to a certain level above which the two normal modes exhibit discontinuity governed mainly by the internal detuning parameter and the system damping ratio. The results are completely different when the second normal mode is externally excited. For small levels of excitation spectral density the response is dominated by the second normal mode. For higher levels of excitation spectral density the first normal mode attends and interacts with the second normal mode in a form of energy exchange. A number of deviations from theoretical results are observed and discussed. Author

A87-33719*# Georgia Inst. of Tech., Atlanta.
A TECHNIQUE FOR THE PREDICTION OF AIRFOIL FLUTTER CHARACTERISTICS IN SEPARATED FLOW
JIUNN-CHI WU, L. N. SANKAR (Georgia Institute of Technology, Atlanta), and K. R. V. KAZA (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 664-673. refs
(Contract NAG3-730)
(AIAA PAPER 87-0910)
A solution procedure is described for determining the two-dimensional, one- or two-degree-of-freedom flutter characteristics of arbitrary airfoils at large angles of attack. The same procedure is used to predict stall flutter. This procedure requires a simultaneous integration in time of the solid and fluid equations of motion. The fluid equations of motion are the unsteady compressible Navier-Stokes equations, solved in a body-fitted moving coordinate system using an approximate factorization scheme. The solid equations of motion are integrated in time using

an Euler implicit scheme. Flutter is said to occur if small disturbances imposed on the airfoil attitude lead to divergent oscillatory motions at subsequent times. Results for a number of special cases are presented to demonstrate the suitability of this scheme to predict flutter at large mean angles of attack. Some stall flutter applications are also presented. Author

A87-33722*# Columbia Univ., New York.
ACOUSTIC FATIGUE - A MONTE CARLO APPROACH
R. VAICAITIS (Columbia University, New York) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 699-708. refs
(Contract NAG1-541)
(AIAA PAPER 87-0916)

The present paper reviews the basic concepts of nonlinear structural response to surface flow and acoustic pressure inputs. A time domain solution and the Monte Carlo method are utilized to estimate the required statistics of the nonlinear response. Simulation procedures of multi-dimensional and multi-variate random processes are discussed. Application of these procedures to acoustic fatigue of flight structures are considered. Numerical examples are included to illustrate the applicability of this method for the solution of nonlinear problems. Author

A87-33733*# Old Dominion Univ., Norfolk, Va.
EFFECTS OF LARGE DEFLECTION AND TRANSVERSE SHEAR ON RESPONSE OF RECTANGULAR SYMMETRIC COMPOSITE LAMINATES SUBJECTED TO ACOUSTIC EXCITATION
CHUH MEI (Old Dominion University, Norfolk, VA) and C. B. PRASAD IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 809-826. refs
(Contract NAS1-17993-22)
(AIAA PAPER 87-0933)

Nonlinear equations of motion of symmetrically laminated anisotropic plates are derived accounting for von Karman strains. The effect of transverse shear is included in the formulation. Using a single-mode Galerkin procedure, the nonlinear modal equation is obtained. The direct equivalent linearization method is employed for solution of this equation. The response to acoustic excitation of moderately thick composite panels is studied. Further, the effects of transverse shear on large deflection vibration of laminates under random excitation are studied. Mean-square deflections and mean-square inplane stresses are obtained for symmetric graphite-epoxy laminates. Using equilibrium equations and the continuity requirements, the mean-square transverse shear stresses are calculated. The results obtained will be useful in the sonic fatigue design of composite aircraft panels. The analysis is presented in detail for simply supported plates. The analogous equations for a clamped case are also obtained. Author

A87-33984#
A NUMERICAL TECHNIQUE FOR THE SOLUTION OF A VAPORIZING FUEL DROPLET
GOPAL PATNAIK (Carnegie-Mellon University, Pittsburgh, PA), WILLIAM A. SIRIGNANO (California, University, Irvine), H. A. DWYER, and B. R. SANDERS (Sandia National Laboratories, Livermore, CA) IN: Dynamics of reactive systems; International Colloquium on Dynamics of Explosions and Reactive Systems, 10th, Berkeley, CA, Aug. 4-9, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 253-266. refs

A technique suitable for investigating fuel droplet vaporization in a hot gas stream is described. The solution technique utilizes a second-order, transient finite-difference code in primitive variables to handle variable density, two-phase flows. The technique has been applied to several cases of single-droplet vaporization in a convecting environment, and a detailed picture of the transport processes throughout the droplet lifetime is presented. Due to drag, the dominance of convection on transport processes gives way to diffusion. Most earlier models assumed the dominance of one mode or the other. C.D.

A87-34272
THE EFFECTIVENESS OF HEAT-PROTECTION COATINGS ON THE BLADES OF GAS TURBINE ENGINES [EFFEKTIVNOST' PRIMENENIIA TEPLOZASHCHITNYKH POKRYTII NA LOPATKAKH GTD]
V. N. KLIMENKO, S. M. CHEPASKINA, and I. M. CHIGAREV (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 8, no. 6, 1986, p. 26-29. In Russian.

A simplified procedure is proposed for evaluating the effectiveness of heat-protection coatings for turbine blades and for calculating the reduction in cooling air consumption and the increase in gas temperature made possible through the use of protective coatings. Results of a computer-aided analysis of the thermal condition of coated and uncoated blades are presented for several existing types of gas turbine engines. It is shown that the use of heat-protection coatings makes it possible to reduce blade temperature by 80-150 K. V.L.

A87-35022#
CRITICALITY OF DELAMINATIONS IN COMPOSITE MATERIALS STRUCTURES
M. BASS, T. GOTTESMAN, and U. FINGERHUT (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 186-190. refs

The reduction in compressive strength of composite sandwich structures due to delaminations in the skins was investigated experimentally and analytically. The influence of the dimensions and the location of the delaminations through the skin thickness on the failure mechanism was studied. Critical locations were found. The experimental study was performed on a 4 point bending sandwich specimen. The analytical approach is based on sublaminate buckling and net section failure calculations. The agreement between experiment and analysis is reasonably good, allowing the use of analysis for real structures. Author

A87-35064
PROFILE MEASUREMENTS USING RADIOGRAPHIC TECHNIQUES
D. A. W. PULLEN (Atomic Energy Research Establishment, Didcot, England) IN: Strain measurement at high temperatures . London and New York, Elsevier Applied Science Publishers, 1986, p. 193-205. refs

The application of profile radiography to the developmental testing of aerogas turbine engines is discussed. Higher X-ray energies or gamma-ray sources such as cobalt-60 or iridium-192 are preferred for use in profile imaging. Factors controlling the geometrical image unsharpness and the image enlargement factor are considered, and it is noted that measurement accuracies within + or - 50-100 microns are readily obtainable from radiographs. Application of the technique to the analysis of gas turbines has yielded qualitative data on internal clearances within the turbine and compressor seals, and the use of video techniques has revealed the sudden motions of profiles during transient conditions within engines. The technique is found to be promising for creep measurements when used in conjunction with extensometry. R.R.

N87-20213# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Theoretical Aerodynamic Group.
NUMERICAL SIMULATION OF INTERNAL AND EXTERNAL INVISCID AND VISCOUS 3-D FLOW FIELDS
STEFAN LEICHER *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 27 p Nov. 1986
Avail: NTIS HC A19/MF A01

A numerical method for solving the 3-D Euler equations in geometrical complex domains was developed. The approach divides the computational space into multiple blocks whose structure follows the natural lines of the conficuration. A systematic, multi-block grid generation scheme is used to produce the grid. The flow solutions are obtained by solving the Euler equations by a finite volume discretization and a Runge-Kutta time stepping scheme. The main advantage of this method is the applicability to complex geometries, for example complete aircraft configurations including wing, fuselage, canard and tail. The coupling with a 3-D boundary layer method allows to account for viscous effects. Another application for the method was the simulation of flows in the presence of a propeller. Author

N87-20222*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
USING THE BOUNDARY-LAYER EQUATIONS IN THREE-DIMENSIONAL VISCOUS FLOW SIMULATION
WILLIAM R. VANDALSEM and JOSEPH L. STEGER *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986 Previously announced as N86-28061
Avail: NTIS HC A19/MF A01

A simple and computationally efficient algorithm for solving the unsteady three dimensional boundary layer equations in a time accurate or relaxation mode is presented. The algorithm is used to compute the separated flow over a 6:1 ellipsoid at angle of attack and the transonic flow over a finite wing with shock induced separation. These results are compared to available experimental data. A method of using the boundary layer algorithm to accelerate a Navier-Stokes computation is also presented. Example computations indicate that a boundary layer algorithm can be used to improve both the accuracy and efficiency of a Navier-Stokes algorithm. Author

N87-20223# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
COMPUTATION OF THREE-DIMENSIONAL FLOWS BY VISCOUS-INVISCID INTERATION USING THE MZM METHOD
M. LAZAREFF and J. C. LEBALLEUR *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 15 p Nov. 1986 In FRENCH; ENGLISH summary
Avail: NTIS HC A19/MF A01

The MZM numerical method (Multi-Zonal-Marching) previously suggested for solving the hyperbolic set of equations of the viscous layers, and the three dimensional turbulent mean velocity profiles modelling suggested for computing separated flows over infinite swept wings, have lead to the development of a very general three dimensional boundary layer method, fit for use on complex geometries, with any prescribed structured mesh, in view of a viscous-inviscid interaction analysis. The method was used successfully for computing transonic wings without separation, with solution of the coupling and rigorous integration of the boundary layer equations starting from the stagnation point. New results are here presented, without coupling, for configurations of ellipsoids of revolution, or flattened ellipsoids, at 30 deg or 60 deg of incidence, and for a geometry of the slender lifting-body type at 30 deg of incidence and 10 deg of yaw angle, with a quasi-total accessibility of the computation domain. These boundary-layer-alone calculations display a flow structure which exhibits a strong analog with accumulations lines, the numerical solution giving access to both sides of these lines. Author

N87-20432# Naval Civil Engineering Lab., Port Hueneme, Calif.
PERFORMANCE OF RECYCLED ASPHALT CONCRETE AIRPORT PAVEMENT SURFACES Final Report, Aug. 1983 - May 1986
G. D. CLINE and M. C. HIRONAKA Oct. 1986 38 p
(Contract DTFA01-83-Y-30593)
(DOT/FAA-PM-86-12; TN-N-1765) Avail: NTIS HC A03/MF A01

The objective of this research was to make an assessment of the relative performance of recycled versus new asphalt concrete pavement surfaces constructed for airport facilities. To make this assessment, pavement condition index (PCI) surveys and tests on core samples from the hot-mix recycled pavements located on the airports at Needles, California, and Valley City, North Dakota were conducted. Both pavements have a condition rating of very good. The survey and test data were compared with those for recycled highway and virgin material Navy airfield pavements. The recycle pavement at Needles is performing as good as those Navy pavements constructed with virgin material. The recycled pavement at Valley City has a higher deterioration rate than the Navy pavements but this could be attributed to the harsh climate found in North Dakota. The results of this study show that hot-mix recycling was successful at these airports but additional studies are required to determine the applicability of Asphalt Concrete (AC) recycling for reconstruction at all airports. Author

N87-20433# Army Cold Regions Research and Engineering Lab., Hanover, N. H.
RESILIENT MODULUS OF FREEZE-THAW AFFECTED GRANULAR SOILS FOR PAVEMENT DESIGN AND EVALUATION. PART 3: LABORATORY TESTS ON SOILS FROM ALBANY COUNTY AIRPORT
D. M. COLE, D. L. BENTLEY, G. D. DURELL, and T. C. JOHNSON Feb. 1987 43 p Sponsored in part by FAA and Army
(Contract PHWA-8-3-0187)
(DOT/FAA-PM-84-16.3; CRREL-87-2) Avail: NTIS HC A03/MF A01

This is the third in a series of four reports on the laboratory and field testing of a number of road and airfield subgrades, covering the laboratory repeated-load triaxial testing of five soils in the frozen and thawed states and analysis of the resulting resilient modulus measurements. The laboratory testing procedures allow simulation of the gradual increase in stiffness found in frost-susceptible soils after thawing. The resilient modulus is expressed in a nonlinear model in terms of the applied stresses, the soil moisture tension level (for unfrozen soil), the unfrozen water content (for frozen soil) and the dry density. The resilient modulus is about 10 GPa for the frozen material at temperatures in the range of -5 to -8 C. The decrease in modulus with increasing temperature was well-modeled in terms of the unfrozen water content. Upon thaw, the modulus dropped to about 100 MPa and generally increased with increasing confining stress and decreased with increasing principal stress ratio. The modulus also increased with the soil moisture tension level. The resilient Poisson's ratio did not appear to be a systematic function of any of the test variables. Author

N87-20517*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC MEASUREMENTS AND THERMAL TESTS OF A STRAIN-GAGE BALANCE IN A CRYOGENIC WIND TUNNEL
RICHMOND P. BOYDEN, ALICE T. FERRIS, WILLIAM G. JOHNSON, JR., DAVID A. DRESS, and ACQUILLA S. HILL Apr. 1987 87 p
(NASA-TM-89039; L-16208; NAS 1.15:89039) Avail: NTIS HC A05/MF A01 CSCL 14B

An internal strain-gage balance designed and constructed in Europe for use in cryogenic wind tunnels has been tested in the Langley 0.3-Meter Transonic Cryogenic Tunnel. Part of the evaluation was made at equilibrium balance temperatures and it consisted of comparing the data taken at a tunnel stagnation temperature of 300 K with the data taken at 200 K and 110 K while maintaining either the Reynolds number or the stagnation

pressure. A sharp-leading-edge delta-wing model was used to provide the aerodynamic loading for these tests. Results obtained with the balance during the force tests were found to be accurate and repeatable both with and without the use of a convection shield on the balance. An additional part of this investigation involved obtaining data on the transient temperature response of the balance during both normal and rapid changes in the tunnel stagnation temperature. The variation of the temperature with time was measured at three locations on the balance near the physical locations of the strain gages. The use of a convection shield significantly increased the time required for the balance to stabilize at a new temperature during the temperature response tests. Author

N87-20555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VIBRATION CHARACTERISTICS OF OH-58A HELICOPTER MAIN ROTOR TRANSMISSION
DAVID G. LEWICKI and JOHN J. COY Apr. 1987 18 p
(NASA-TP-2705; E-3368; NAS 1.60:2705; AVSCOM-TR-86-C-42)
Avail: NTIS HC A01/MF A01 CSCL 01C

Experimental vibration tests covering a range of torque and speed conditions were performed on the OH-58A helicopter main rotor transmission at the NASA Lewis Research Center. Signals from accelerometers located on the transmission housing were analyzed by using Fourier spectra, power spectral density functions, and averaging techniques. Most peaks of the Fourier spectra occurred at the spiral bevel and planetary gear mesh harmonics. The highest level of vibration occurred at the spiral bevel meshing frequency. Transmission speed and vibration measurement location had a significant effect on measured vibration; transmission torque and measurement direction had a small effect. Author

N87-20556*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL AND ANALYTICAL EVALUATION OF DYNAMIC LOAD AND VIBRATION OF A 2240-KW (300-HP) ROTORCRAFT TRANSMISSION
FRED K. CHOY, DENNIS P. TOWNSEND, and FRED B. OSWALD Mar. 1987 18 p Presented at the Design Engineering Conference and Show, Chicago, Ill., 2-5 Mar. 1987; sponsored by ASME
(NASA-TM-88975; E-3380; NAS 1.15:88975) Avail: NTIS HC A02/MF A01 CSCL 13I

A dynamic analysis of a 2240-kW (3000-hp) helicopter planetary system is presented. Results from both analytical and experimental studies show good correlation in gear-tooth loads. A parametric study indicates that the mesh damping ratio has a significant effect on maximum gear tooth load, stress, and vibration. Correlation with experimental results indicates that the Sun-planet mesh damping ratio can significantly differ from the planet ring mesh damping ratio. A numerical fast Fourier transform (FFT) procedure was applied to examine the mesh load components in the frequency domain and the magnitudes of multiple tooth pass frequencies excited by nonsynchronous meshing of the planets. Effects of tooth-spacing errors and tooth-profile modifications with tip relief are examined. A general discussion of results and correlation with the experimental study are also presented. Author

N87-20566*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SHOT PEENING FOR TI-6AL-4V ALLOY COMPRESSOR BLADES
GERALD A. CAREK Apr. 1987 9 p
(NASA-TP-2711; E-3430; NAS 1.60:2711) Avail: NTIS HC A01/MF A01 CSCL 20K

A text program was conducted to determine the effects of certain shot-peening parameters on the fatigue life of the Ti-6Al-4V alloys as well as the effect of a demarcation line on a test specimen. This demarcation line, caused by an abrupt change from untreated surface to shot-peened surface, was thought to have caused the failure of several blades in a multistage compressor at the NASA Lewis Research Center. The demarcation line had no detrimental effect upon bending fatigue specimens tested at room temperature. Procedures for shot peening Ti-6Al-4V compressor blades are recommended for future applications. Author

N87-21166# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ACTIVITIES REPORT IN STRUCTURES Annual Report, 1985
Oct. 1986 26 p Original contains color illustrations
(ETN-87-99375) Avail: NTIS HC A03/MF A01

A stiffened plate macro-element; a macro-element of elastic pipe filled with liquid; modeling of the structural fuzzy in medium frequency computations; unsteady aerodynamic forces on jet engine air intakes; prediction of buffeting vibrations from unsteady pressure measurements taken in a wind tunnel; aeroelastic behavior of fan blades in the unstarted supersonic domain; wind tunnel study of a helicopter blade stall control; computer-controlled generator of turbulence in a wind tunnel; atmospheric turbulence statistics; adaptation of Neuber's theory to viscoplastic stress concentration; computation of a jet engine disk/flange assembly; and analysis of the damage done to a perforated composite plate under biaxial monotonic and cyclic loading are described. ESA

N87-21170# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
ADVANCED INSTRUMENTATION FOR AERO ENGINE COMPONENTS [IN ENGLISH AND FRENCH]
Loughton, England Nov. 1986 556 p Symposium held in Philadelphia, Pa., 19-23 May 1986
(AGARD-CP-399; ISBN-92-835-0401-1) Avail: NTIS HC A24/MF A01

The Symposium was addressed to research scientists and development engineers for aero engines in order to discuss the state-of-the-art and to be informed on new measurement possibilities. The scope included Coherent Anti-Stokes Raman Spectroscopy (CARS), laser anemometry, pyrometry, clearance measurement including X-ray, high speed data acquisition and processing, stress measurement and vibration and thin layer technique, unsteady and transient phenomena, and future prospects.

N87-21181# Pratt and Whitney Aircraft, East Hartford, Conn.
LASER VELOCIMETRY STUDY OF STATOR/ROTOR INTERACTIONS IN A MULTI-STAGE GAS TURBINE COMPRESSOR
M. CARLSON WILLIAMS *In* AGARD Advanced Instrumentation for Aero Engine Components 10 p Nov. 1986
Avail: NTIS HC A24/MF A01

The measurement of airflow through multi-stage compressor rigs has generally been limited to the use of flow perturbing pressure and temperature probes. Although limited studies of the dynamics of these flows have been obtained with hot wire and hot film probes, the advent of the laser Doppler velocimeter (LDV) with its non-perturbing nature is expected to develop into the preferred instrumental method. To assess the feasibility of utilizing an LDV in these flows an exploratory program was recently undertaken at Pratt and Whitney. A multi-stage compressor rig, the Energy Efficient Engine high pressure compressor consisting of 6th through 15th compressor stages, was outfitted with windows between the 6th stator-7th rotor, 9th stator-10th rotor, and 13th stator-14th rotor. The windows, extending circumferentially one stator gap wide, permitted the hub to tip traversing midway between the stator trailing edge and the rotor leading edge both in and out of the stator wakes. A confocal two color, two component back scatter LDV system developed for use in gas turbine environs was employed to obtain detailed mappings to velocity magnitude and air angle as a function of rotor position at several spanwise and gapwise positions downstream of the 6th and 9th compressor stators. Although a complete mapping was not obtained, sufficient data was acquired behind the 13th stator to identify the flow's character there as well. The equipment employed in this study and the difficulties encountered are described. Author

N87-21187# Land Turbine Sensors, Inc., Tullytown, Pa.
SOME CONSIDERATIONS RELATING TO AERO ENGINE PYROMETRY
P. J. KIRBY *In* AGARD Advanced Instrumentation for Aero Engine Components 14 p Nov. 1986
Avail: NTIS HC A24/MF A01

With turbine blade optical pyrometry rapidly becoming accepted by the aerospace community as a viable flight control technique, some of the traditional and emerging demands are described, with examples of how they are being addressed. Many of these demands are now being met by skillful application of materials technology, electronic engineering, signal processing and fluid flow techniques, but it is probable that flight conditions will impose a more pragmatic approach than customarily adopted towards test bed installations. Author

N87-21191# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
ACQUISITION AND PROCESSING OF NON-STATIONARY PRESSURE MEASURMENTS IN STUDIES OF AIR INTAKE DISTORTION [ACQUISITION ET TRAITEMENT DES MESURES DE PRESSIONS NON STATIONNAIRES DANS LE CADRE DES ETUDES DE DISTORSION DENTREES DAIR]
J. L. EYRAUD, F. AUZOLLE, and M. WAGNER (Office National d'Etudes et de Recherches Aerospatiales, Paris, France) *In* AGARD Advanced Instrumentation for Aero Engine Components 7 p Nov. 1986 In FRENCH
Avail: NTIS HC A24/MF A01

Investigations of compatibility between an aircraft air intake and the engine constitute an essential stage in the improvement of new concepts. This work is based on an experimental activity which, for full exploitation of the conditions, requires that the most complete data acquisition and processing techniques be employed. The methods described illustrate the full range of presently operational analog and digital systems. Particular emphasis is given to the importance of continuous real time analysis. Author

N87-21195# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
THE UTILIZATION OF THIN FILM SENSORS FOR MEASUREMENTS IN TURBOMACHINERY [UTILISATION DES CAPTEURS PELLICULAIRES POUR LA MESURE SUR TURBOMACHINES]
A. BRUERE, M. PORTAT, J. C. GODEFROY, and F. HELIAS *In* AGARD Advanced Instrumentation for Aero Engine Components 9 p Nov. 1986 In FRENCH Original language document was announced as A86-46180
Avail: NTIS HC A24/MF A01

Sensor features and data analysis principles for thin films used as pressure and temperature transducers for flowfield measurements in turbomachinery are described. The devices were developed to collect data without affecting the flowfield around fixed and rotating turbine blades. The concept has been extended to thermal fluxmeters for measuring convection of the thermoelectric effect and to measuring the aerodynamics of boundary layer flows by exploiting temperature-induced changes in the resistivity of certain metals. The films have a maximum thickness of 80 microns, can be integrated into the walls of the area under investigation by vapor phase deposition, and require adhesive layers of only 2 to 4 microns. Numerical models are furnished for solid and gaseous dielectric sensor films for pressure measurements and for relating data from a thermal fluxmeter to temperature fields of flow. Author

N87-21202# Warwick Univ. Coventry (England). Dept. of Engineering.
THE APPLICATION OF HOLOGRAPHY AS A TRANSONIC FLOW DIAGNOSTIC TO ROTATING COMPONENTS IN TURBOMACHINERY
P. J. BRYANSTON-CROSS *In* AGARD Advanced Instrumentation for Aero Engine Components 22 p Nov. 1986
Avail: NTIS HC A24/MF A01

A review is presented of the application of holography as a whole field flow visualization diagnostic in turbomachinery. Starting with two dimensional cascade testing, which required wavelength toleranced optical tables, it has now been found possible to obtain results with bolt-on optical components. In order to achieve this, compromises have been made in optical quality and attention has been given to the nature of the data required. Holographic systems are shown which have been applied to visualize the flow in a linear cascade, an annular cascade, a three dimensional compressor shock in a rotating flow and a diffuser blockage observed in a rotating turbocharger. Author

N87-21214# Naval Research Lab., Washington, D. C.
A QUICK LOOK AT THE FIRST NRL SHORT PULSE 95 GHZ RADAR FLIGHT DATA
C. S. LIN and A. C. MILLER 12 Dec. 1986 15 p
(AD-A176182; NRL-MR-5891) Avail: NTIS HC A02/MF A01 CSCL 17G

A new high resolution 95 GHz radar system was incorporated into an existing high speed data acquisition system installed on a NRL RP-3A aircraft. The radar can be operated in either short pulse mode (pulse width 10 nanoseconds) or long pulse mode (pulse width 50 nanoseconds). The high speed data acquisition system can sample the radar return waveforms with total burst rate of up to 500 KHz. A series of measurements was made over the Great Dismal Swamp and the Atlantic Ocean. The radar was deployed in the Altimeter mode during the Dismal Swamp measurements, while both the Altimeter and Aft-looking mode were deployed over the ocean. Representative data are presented. GRA

N87-21246# Boeing Military Airplane Development, Seattle, Wash.
FAULT TOLERANT ELECTRICAL POWER SYSTEM. PHASE 1: STUDY Interim Technical Report, Apr. - Jun. 1985
MARK W. DIGE, PATRICK J. LEONG, and DAVID L. SOMMER Dec. 1986 52 p
(Contract F33615-85-C-2504)
(AD-A177061-PH-1; D180-28576-2-PH-1; AFWAL-TR-86-2084-1-PH-1) Avail: NTIS HC A04/MF A01 CSCL 01C

The objectives of this program are to develop a fault tolerant electrical power system (FTEPS) design for an ATF aircraft and to design and fabricate a low cost FTEPS demonstrator with an integrated load simulator. The primary purpose of the program is to develop an electrical power generation and distribution system that can supply electrical power to the various critical systems on the aircraft with a reliability and power quality level commensurate with the requirements of the loads. In Phase 1, the electrical loads and their power requirements were defined for the ATF baseline aircraft model. The loads were also located in the baseline aircraft model. GRA

N87-21265# Naval Postgraduate School, Monterey, Calif.
TRANSONIC COMPRESSOR BLADE TIP FLOW VISUALIZATION ON A WATER TABLE M.S. Thesis
ALAN K. BYRD Dec. 1986 58 p
(AD-A176592) Avail: NTIS HC A04/MF A01 CSCL 20D

The shock structure at the tip of a transonic compressor rotor was investigated on a water table. A four bladed cascade model was used and the wave pattern was examined at variable incidence, flow turning angles and back-pressures. Froude numbers, (equivalent to Mach numbers in the analogous two dimensional gas flow), in the range 1.6 to 1.74 resulted in an oblique shock between the blade passages starting from the leading edge

pressure side of the blading. Qualitative agreement of the shock structure with earlier tests using the same blading in a transonic blow-down tunnel was observed, leading to the conclusion that the shock present in the compressor would be oblique and not normal as was previously assumed. GRA

N87-21341# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
FLUID DYNAMICS OF HIGH PERFORMANCE TURBOMACHINES Annual Report, 19 Oct. 1985 - 18 Oct. 1986
EDWARD M. GREITZER, ALAN H. EPSTEIN, MICHAEL B. GILES, JAMES E. MCCUNME, and CHOON S. TAN Nov. 1986 89 p
(Contract F49620-85-C-0018)
(AD-A177003; AFOSR-87-0038TR) Avail: NTIS HC A05/MF A01 CSCL 13G

This report describes work which is part of a study on high performance turbomachinery fluid dynamics. Within the general topic, four separate tasks studies include: (1) loss mechanisms and loss migration in transonic compressors, including development of advanced instrumentation for measurements of wake radial transport and analysis of unsteady vortical wake structures; (2) experimental and theoretical study of flows in casing and hub treatment, including mechanisms for stability enhancement in compressors and unsteady fluid dynamic interactions between passage and groove flows; (3) computational techniques for turbomachinery, including inverse (design) calculation procedures for transonic turbomachine blades accounting for viscid/inviscid interaction; and (4) theoretical modelling of stability and unsteadiness in transonic compressor flow fields, including analyses of unsteady temperature fluctuations due to vortex shedding. GRA

N87-21373*# Textron Bell Helicopter, Fort Worth, Tex.
SUMMARY OF THE MODELING AND TEST CORRELATIONS OF A NASTRAN FINITE ELEMENT VIBRATIONS MODEL FOR THE AH-1G HELICOPTER, TASK 1 Final Report
J. D. CRONKHITE, V. L. BERRY, and R. V. DOMPKA Jan. 1987 278 p
(Contract NAS1-17496)
(NASA-CR-178201; NAS 1.26:178201; REPT-699-099-202)
Avail: NTIS HC A13/MF A01 CSCL 20K

The AH-1G NASTRAN finite element model (FEM) is described and the correlations with measured data that were conducted to verify the model are summarized. Comparisons of the AH-1G NASTRAN FEM calculations with measured data include the following: (1) fuselage and tailboom static load deflection (stiffness) testing, (2) airframe ground vibration testing (0-30 H<), (3) airframe flight vibration testing (main rotor, 2,4, and 6/rev), and (4) tailboom effective skin static testing. A description of the modeling rationale and techniques used to develop the NASTRAN FEM is presented in conjunction with all previous correlation work. In general, the correlations show good agreement between analysis and test in stiffness and vibration response through 15 to 20 Hz. For higher frequencies (equal to or greater than 4/rev (21.6 Hz)), the vibration responses generally did not agree well. Also, the lateral (2/rev (10.8 Hz)) flight vibration responses were much lower in the FEM than test, indicating that there is a significant excitation source other than at the main rotor hub that is affecting the lateral vibrations, such as downwash impingement on the vertical tail. Author

N87-21378# Aerospace Structures Information and Analysis Center, Wright-Patterson AFB, Ohio.
A TWO-DIMENSIONAL LINEAR ELASTIC CRACK TIP ELEMENT FOR NASTRAN Interim Technical Report, Mar. - May 1985
PETER J. WOYTOWITZ and RICHARD L. CITERLEY Jul. 1986 63 p
(Contract F33615-84-C-3216)
(AD-A176133; ASIAC-685.1D; AFWAL-TR-86-3018) Avail: NTIS HC A04/MF A01 CSCL 20K

Linear elastic fracture mechanics has gained a substantial acceptance in industry and has become one of the most important design considerations. Many engineering structures such as airplanes, turbines, piping (pressure vessels), bridges, etc., contain pre-existing flaws. As a result of even rather moderate service loads, crack propagation resulting from these flaws can have a dramatic effect on the service life of the component. To account for this reduction in service life, fracture mechanics analysis in conjunction with a fracture control plan is generally implemented. A new crack element has been developed and incorporated into COSMIC/NASTRAN. The element is considered linear, isotropic, and homogeneous. Mode I and II stress intensity factors are automatically calculated. Comparisons to theoretical plane strain solutions for several geometries are presented and demonstrate the accuracy of the developed element. Extensions of the element to three dimensions, anisotropic material, and plastic analysis are discussed. GRA

N87-21401# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
FINITE ELEMENT ANALYSIS OF THREE-DIMENSIONAL STRUCTURES USING ADAPTIVE P-EXTENSIONS
BOERJE ANDERSSON and URBAN FALK Oct. 1986 21 p
Presented at NATO Advanced Study Institute on Computer Aided Optimal Design: Structural and Mechanical System, Troia, Portugal, 29 Jun.-11 Jul. 1986
(Contract FMV:FFL-82250-85-076-73-001)
(FFA-TN-1986-57; ETN-87-99445) Avail: NTIS HC A02/MF A01

Linear elastic small displacement and small strain analysis of three-dimensional structures are treated. The p-version of the finite element method is used where basis functions are complete polynomials of order P less than or=12. A FORTRAN-program operative on CRAY-computers is used to analyze three dimensional domains where the exact solutions exhibit singularities at lines and points. The asymptotic rate of convergence observed is discussed in view of known characteristics of the exact solutions close to corners. Results indicate that the rate of convergence of the finite element solutions is governed by the strength of a line singularity. It is demonstrated that solutions obtained using adaptively constructed p-extensions lead to a high rate of convergence in the energy norm compared to strategies where uniform h, or p-extensions are used. ESA

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GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A87-34445
AVIATION AND SATELLITE CLIMATOLOGY [AVIATSIONNAIA I SPUTNIKOVAIA KLIMATOLOGIIA]
G. V. LESNIKOVA, ED., Z. M. MAKHOVER, ED., and V. I. TITOV, ED. Moscow, Gidrometeoizdat (Vsesoiuznyi Nauchno-Issledovatelz'-skii Institut Gidrometeorologicheskoi Informatsii - Mirovoi Tsentr Dannykh, No. 126), 1986, 104 p. In Russian. For individual items see A87-34446 to A87-34449.

Papers are presented on such topics as the zonal features of the statistical structure of the global cloud field; the distribution of cloud cover over tropical Africa; the remote sensing of precipitation over the Atlantic Ocean using the Meteor satellite; and water-vapor transport in the troposphere above the Indian Ocean during a summer monsoon. Consideration is also given to the effects of atmospheric turbulence on aircraft during takeoff and landing, the diffusion of impurities in the atmospheric boundary layer, and an objective analysis of climatic temperature fields in the free atmosphere above the USSR. Particular emphasis is placed on weather conditions that are hazardous to aircraft flight. B.J.

A87-34449
DESCRIPTION OF THE VERTICAL STRUCTURE OF THE WIND FIELD BY THE METHOD OF CANONICAL EXPANSIONS [OPISANIE VERTIKAL'NOI STRUKTURY POLIA VETRA METODOM KANONICHESKIKH RAZLOZHENII]
IU. P. KISHKOVICH IN: Aviation and satellite climatology . Moscow, Gidrometeoizdat, 1986, p. 92-96. In Russian. refs
The vertical structure of the wind field is described by canonical expansions of a random function, making it possible to account for correlations between wind velocities at different heights and to statistically model the wind field. A formula is proposed for determining the conditional mathematical expectation of wind at a certain height according to its measured value. It is noted that the present results can be used to study the effect of wind on flight vehicles. B.J.

A87-34514*# Michigan Technological Univ., Houghton.
TURBULENCE STRUCTURE IN MICROBURST PHENOMENA
GEORGE TREVINO (Michigan Technological University, Houghton) Journal of Aircraft (ISSN 0021-8669), vol. 24, April 1987, p. 283-285. NASA-supported research. refs
The efect on turbulence of a variable mean wind along the flight path of an aircraft is modeled and analyzed. It is found that the effect of a variable head or tail wind alters the magnitude of the length-scale of sensed microburst turbulence, rendering turbulence more random than usually encountered in the upper atmosphere. This, coupled with accompanying aerodynamic lift loss experienced during the headwind-to-tailwind swing, is what collectively creates the hazardous environment for a microburst-encountering aircraft attempting to land during a thunderstorm. O.C.

A87-35000#
AERONAUTICAL METEOROLOGY IN PRACTICE [METEOROLOGIA AERONAUTICA DAL VIVO]
ABELE NANIA and GINO TODISCO (Aeronautica Militaire Italiana, Servizio Meteorologico, Rome, Italy) Rivista di Meteorologia Aeronautica (ISSN 0035-6328), vol. 46, Jan.-June 1986, p. 3-17. In Italian.
Meteorological techniques for detecting and predicting strong convective turbulence affecting air traffic are surveyed, using an encounter experienced by a group of Italian air meteorologists over Salerno on October 1, 1984 as an example. The sudden onset and severity of the turbulence effects are described, and the use of Meteosat thermal-IR maps (in conjunction with conventional ground data) to analyze the weather situation is discussed in detail and illustrated with graphs, maps, sample images, and a diagram of the giant-anvil structure formed on the day of the encounter. A wind-shear incident which occurred at Reggio Calabria airport on the same day is briefly characterized. T.K.

N87-20706# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de la Physique Generale.
LIGHTNING STRIKES ON AIRCRAFT. EXPLOITATION OF LANDES (FRANCE)-FRONT '84 CAMPAIGN AND COMPLEMENTARY DEVELOPMENT OF AIRBORNE ELECTRICAL SENSORS Final Report [FOUDROIEMENTS DES AERONEFS. EXPLOITATION DE LA CAMPAGNE LANDES-FRONT 84 ET DEVELOPPEMENT COMPLEMENTAIRE DE CAPTEURS ELECTRIQUES EMBARQUABLES]
P. LAROCHE, A. BONDIOU, A. DELANNOY, P. GONDOT, and P. RICHARD Aug. 1986 160 p In FRENCH
(Contract DRET-85-001)
(ONERA-RF-91/7154-PY; ETN-87-99383) Avail: NTIS HC A08/MF A01
The localization of atmospheric discharges obtained by a 300 MHz electromagnetic interferometer are compared to the radar signatures giving the precipitation rate and wind fields inside the convective cells. The data are complemented by onboard measurements of electric field and hydrometeors, made using sensors placed on the structure of a Transall aircraft. Results show a clear correlation between Doppler radar and interferometric simultaneous images. Electrical simultaneous onboard measurements such as electric field, ionic conductivity, precipitation charges, are, as suspected, strongly correlated. ESA

N87-21456# European Space Agency, Paris (France).
DETERMINATION OF VERTICAL AIR VELOCITY USING MEASUREMENTS OF THE AIRCRAFT MOTION
MARKUS HUTTER *In its* Proceedings of Meteorological Motor Glider (MEMO) Workshop '84 (ESA-TT-945) p 30-42 Nov. 1986 Transl. into ENGLISH from "Beitrage zum Workshop MEMO (Meteologischer Motorsegler)" DFVLR, *Oberpfaffenhofen*, West Germany, report DFVLR-Mitt-85-04, Jan. 1985 p 29-42 Original language document was announced as N85-35545
Avail: NTIS HC A10/MF A01; original German version available from DFVLR, Cologne, West Germany DM 53
Absolute air velocity is determined from the movements of an aircraft. Determination of aircraft motion in a vertical plane is described; the vertical equation of motion and the calculation of an average position angle are discussed. Good agreement is found between measured and calculated angles. The sensitivity of the results to the position angle is discussed. ESA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A87-31453
AUTOMATING THE SOFTWARE DEVELOPMENT PROCESS
MARK R. BLACKBURN and ROBERT D. BUSSER (Allied-Signal, Inc., Bendix Avionics Div., Fort Lauderdale, FL) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 20-27. refs
This paper presents the attributes of the Automated Software Development Methodology, ASDM, which supports automation. ASDM is a knowledge-based expert system that supports a mathematically formal methodology based on a nontraditional software development paradigm. The methodology uses a systematic process based on Dijkstra's constructive approach for constructing provably consistent and complete requirement and design specifications, and provably correct transformations from their specifications. Author

A87-31472
ADVANCED AVIONICS DISPLAY PROCESSOR ARCHITECTURE
BARRY KROFCHICK (Litton Systems Canada, Ltd., Toronto) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 177-182. refs
The changing role of the pilot in next generation fighter aircraft is discussed. This leads to a new set of requirements for next generation avionics display formats, and hence display processors. The need for an avionics graphics interface which can handle complex imagery and associated picture dynamics without overburdening the mission computer or the avionics bus is established. The Litton Graphics System (LGS), an interface command language, and also an advanced avionics Display Processor functional specification, is presented. LGS picture representation, and generation models are discussed, along with multiple display facilities, geometric modelling and special graphics features. Author

A87-31475
A GRAPHICS ORIENTED DESIGN LANGUAGE FOR CONTROL SOFTWARE
D. D. MORTON (Allied-Signal, Inc., Bendix Energy Control Div., South Bend, IN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 196-203.

A graphic design language which generates code, called GODEL, is discussed. GODEL translates graphic information into a target language which is determined by a set of 'templates' contained in a 'code-generation' file. The target language need only be sufficiently powerful to handle simple arithmetic/logical operators, subroutines, decisions, and a common type of storage allocation. The features and benefits of this software development are explained, using the process of designing software for digital control of gas turbine engines as an illustration. C.D.

A87-31477
PROTOTYPE REAL-TIME SIMULATION SOFTWARE FOR THE CONCURRENT MULTIPROCESSING ENVIRONMENT
JOSEPH H. LITTLE and RONALD R. RITER (Boeing Computer Services Co., Seattle, WA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 209-211.

This paper is to report on the status and results associated with ongoing research and development on techniques for utilizing highly modular concurrent multiprocessors for commercial airplane simulation and test. An effort was undertaken to determine the feasibility and software requirements for a simulation system that: (1) is faithful to the avionics environment simulated; (2) attains low cost modularity through concurrent multiprocessor architectures; (3) uses industry standards such as chip sets, busses, networking, and UNIX operating system; and, (4) maintains commonality of system elements such as real time and development. Particular emphasis is placed on the real-time software environment and the transition from simulation development to real-time execution. Author

A87-31479
DIGITAL AUTONOMOUS TERMINAL ACCESS COMMUNICATION (DATAC)
JOHN L. SHAW, HANS K. HERZOG (Boeing Commercial Airplane Co., Seattle, WA), and KENJI OKUBO (NEC Corp., Tokyo, Japan) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 221-226.

Rapid changes in the capabilities and complexities of avionic systems, along with the increasing dependency on these systems, mandates that the basic capabilities of the digital data bus system should be upgraded to match those of the using systems. Past methods of point to point wiring (unidirectional) results in higher wire count, higher wire weight and higher manufacturing costs. Boeing is developing a totally new airplane, utilizing technologies never before available on jetliners. Data transfer is required for the fly-by-wire, throttle by wire control, Avionics intercommunication, remote sensor implementation and remote control of many aircraft systems. Boeing has developed an advanced digital bus (DATAC) which has all the primary characteristics required for use in an advanced commercial transport airplane. The DATAC bus is a high speed bidirectional data bus which operates autonomously and is independent of any specific LRU. It is the result of over 40 man years of research and development at the Boeing Company. NEC has undertaken the design, manufacture and distribution of a CMOS LSI terminal in a single chip implementation. Author

A87-31480*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
GLOBAL SYSTEM DATA BUS USING THE DIGITAL AUTONOMOUS TERMINAL ACCESS COMMUNICATION PROTOCOL
DAVID C. E. HOLMES (NASA, Langley Research Center, Hampton, VA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 227-233.

Modern digital avionic systems with distributed processing require networking to connect the many elements. Digital Autonomous Terminal Access Communication (DATAC) is one of many such networks. DATAC has been implemented on the Transport Systems Research Vehicle (TSRV), a Boeing 737 aircraft operated by the National Aeronautics and Space Administration's Advanced Transport Operating Systems Program Office (ATOPS). This paper presents the TSRV implementation of the DATAC bus, a description of the DATAC system, a synchronization mechanism, details of data flow throughout the system, and a discussion of the modes available with DATAC. Numerous flight tests have been conducted using DATAC as the only means of communication between systems with outstanding results. DATAC is now an integral part of the TSRV and is expected to satisfy near term as well as future requirements for growth and flexibility. Author

A87-31481
SAE AE-98 DRAFT STANDARD HIGH SPEED TOKEN PASSING DATA BUS FOR AVIONICS APPLICATIONS
JOHN W. MEYER (Boeing Military Airplane Co., Wichita, KS) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 234-241.

The dramatic increase in data transmission requirements for modern avionics systems and the need to allow resource sharing between multiple avionics subsystems has mandated the development of a high speed data bus to allow integration of these systems. This paper presents an overview of the work accomplished to date by the SAE AE-98 Linear implementation Task Group and details the design activities and considerations for the proposed standard linear token passing bus, reliability and testability issues, and a brief discussion of future activity. Author

A87-31482#
SIMULATION MODEL OF A HIGH-SPEED TOKEN-PASSING BUS FOR AVIONICS APPLICATIONS
JAMES E. SPIETH (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) and WALTER D. SEWARD (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 242-249. refs

There are many factors of bus token-passing protocols that influence the overall performance of the protocol. Extensive analysis is needed to design a protocol with performance that can meet the requirements for a next-generation aviation electronics (avionics) data bus. This paper describes a study effort that developed and validated a model for simulating bus token-passing protocols for avionics applications. Two algorithms were designed that reflected the timing and operation of a distributed and a centralized control token-passing protocol. The algorithms were incorporated into an overall simulation model program which included control, data collection and analysis functions. The simulation model program allows various avionics bus configurations to be defined and tested. Initial performance tests were conducted for a centralized control token-passing protocol using a configuration representative of a fighter-type aircraft bus network. The performance of the two types of protocols was also compared. Author

A87-31483

AVIONICS STANDARD COMMUNICATIONS BUS - ITS IMPLEMENTATION AND USAGE

RANDLE G. JENNINGS (Sperry Corp., Aerospace and Marine Group, Glendale, AZ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 250-254.

The Avionics Standard Communications Bus (ASCB) was developed to meet the needs of digital avionic system communications in today's aircraft. ASCB is a high-speed (2/3 MHz), bi-directional bus that uses industry standard protocol (HDLC) and components to link all of the avionic and aircraft subsystems. ASCB was developed for the aviation marketplace and utilizes a number of features both in software and hardware to provide the safety and redundancy that is required for aircraft data bus networking. ASCB is presently certified in a number of business jets and commuter turboprop airplane applications and has the growth to meet today's applications as well as any future applications. The General Aviation Manufacturers Association (GAMA) has supported ASCB as one of the standard data buses used in the general aviation and business airplane market. Author

A87-31495

A QUANTITATIVE ANALYSIS OF THE HISTORY OF DEVELOPING A LARGE EMBEDDED SOFTWARE SYSTEM

MICHAEL R. CRAMER (Lear Siegler, Inc., Instrument and Avionics Systems Div., Grand Rapids, MI) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 355-362.

Detailed empirical studies of large, real-time avionics software development projects are rare due to the difficulty of collecting accurate and complete quantitative data on the progression of the project. Extensive data histories were maintained during the development of the Lear Siegler Flight Management Computer System (FMCS) for the Boeing 737-300 aircraft through use of an automated source code library and an extensive problem reporting (PR) database system. The data include some five thousand problem reports, the histories of eighteen hundred modules and 140,000 lines of executable code. In particular, specific numerical data are presented regarding the types and numbers of problems found by each level of development testing, the relationship between error rates and software complexity is quantified, and numbers of nonproblems reported are discussed. Specific areas are identified where modified management and/or technical approaches would appear to have benefited the development of the FMCS. Author

A87-31496

A SOFTWARE QUALITY ASSURANCE TOOL FOR CODE AUDITING

E. N. HAIR and L. S. PERRY (General Dynamics Corp., Fort Worth, TX) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 363-369.

At General Dynamics, Fort Worth Division (GD/FW), there evolved a need in the area of avionic software to conduct code audits of large operational flight programs. The purpose of the auditing was to assure that the software delivered to the customer conformed to certain tenets of good programming practice. Initially, the auditing task was done manually and proved to demand an inordinate amount of time. Also, since the audits were conducted by different individuals, the audit results were inconsistent as they were subject to personal bias and varying interpretations of programming standards. It was determined that an automated tool would more appropriately fulfill the need for code auditing and a project was undertaken to develop such a tool. This paper discusses the project in terms of how the need for it arose, its implementation as a software development effort, preliminary results of tool use, and expected project benefits. Author

A87-31497

DIGITAL PROCESSING FOR EMERGING AVIONICS SYSTEMS

JAMES F. PITTS and VINCENT S. ZAGARDO (Westinghouse Electric Corp., Baltimore, MD) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 373-381.

This paper discusses the methodology utilized to derive a digital avionics architecture and the requirements utilized to derive the subsequent tradeoff analyses. A resultant digital avionics architecture is described, outlining its overall performance and the constituent signal and mission processing module set. The approach is highly synergetic with ongoing development programs with extremely high payoff (size, weight, and power) through effective utilization of high performance fixed point and floating point processor modules. 3/4 ATR packaging approaches are discussed along with reliability and maintainability characteristics. A distributed fault tolerant operating system is described along with a complete support software environment that facilitates programming at the Ada level. Author

A87-31507

FLIGHT CONTROL SOFTWARE FOR TEST GENERATION

E. R. RANG and K. H. THELEN (Honeywell, Inc., Systems and Research Center, Minneapolis, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 445-447.

A prototype expert work station has been constructed to generate tests for Ada units. The control structure of the Ada program is automatically extracted and is represented as a decision table. A compiler syntax analyzer has been modified to accomplish this. The conditions and the rules of the decision are then translated into PROLOG and become the input to the interactive test generator. After some experience is gained in applying this prototype to flight control units written in Ada, the control analyzer will be rewritten using a full Ada compiler, and the expert system will be extended to be more complete. This system will be part of a comprehensive methodology that formally represents the specifications in executable language. Thus, the specifications will be testable and will act as test monitors for integration testing. Author

A87-31508

SOME VIEWS ON THE USE OF ADA FOR DIGITAL FLIGHT CONTROL SYSTEMS

T. G. LAHN, SPENCER E. MINEAR, and JAMES MURRAY (Honeywell, Inc., Military Avionics Div., Minneapolis, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 455-460. refs

The introduction of the Ada computer language into the development of Digital Flight Control Systems (DFCS), presents a number of interesting technical challenges. This paper provides a list of special requirements for DFCS software, a list of unique features of the Ada language, and a discussion of the interaction of these two lists of issues. The paper includes a summary of how Honeywell is addressing these problems and provides some conclusions based on the current work with Ada applied to DFCS development. Author

A87-31509

RECONFIGURABLE DISPLAY PANEL USING EMBEDDED ADA

THOMAS J. DAHLIN and DONALD G. KRANTZ (Honeywell, Inc., Defense Systems Div., Minnetonka, MN) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 461-465. Research supported by Honeywell, Inc.

This paper describes the implementation of a Reconfigurable Control and Display Unit (RCDU) programmed in Ada, running on an embedded 8086 microprocessor. The RCDU was developed for combat vehicle control and display applications requiring a

menu-driven, self-prompting operator interface. It uses a 4 x 8-in. electroluminescent panel for information and graphics display. The display is overlaid with an infrared 'touch screen', thus enabling the generation of individual switches, key-pads, gauges and other annunciators under software control. The impact of Ada on the RCDU's system design is described, and the hardware/software tradeoffs made. Software runtime overhead will be discussed, as well as a report on two different Ada compilers for the embedded 8086. Author

A87-31517
REAL-TIME FAULT TOLERANT SOFTWARE IN DISTRIBUTED AVIONICS SYSTEMS ARCHITECTURES USING DIGITAL DATA BUSES
ELLIS F. HITT (Battelle Columbus Laboratories, OH) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 523-528. refs

Real-time fault tolerant multi-version and recovery block software techniques, and problems confronted in applying them to avionics system architectures using distributed multiprocessing networks that employ standard digital avionics data buses are described. Also described is the impact of emerging software engineering tools, resulting from application of knowledge based systems and software simulators, on avionics software development. Author

A87-31536
CHANNELIZED OR NONCHANNELIZED FAULT-TOLERANT COMPUTERS - A HARDWARE COMPLEXITY COMPARISON OF FAULT-TOLERANT COMPUTERS FOR FLIGHT CONTROL SYSTEMS
HERMANN SCHMID, STANLEY LARIMER, and THOMAS MADAK (General Electric Co., Binghamton, NY) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 655-663. refs

The flight control systems of such future military aircraft as the ATF will require not only greater reliability, fault tolerance, and computing power, but also easier maintenance and reduced life cycle costs. Attention is presently given to the hardware complexity of reconfigurable multiprocessor systems (RMPSs), for which greater hardware efficiency and lower recurring costs are claimed in exchange for greater software and system complexity. Gate and pin counts are compared among four fault-tolerant computer architectures. It is found that, at higher levels of fault tolerance, a properly designed RMPS yields a more software-efficient solution than alternatives. O.C.

A87-31537* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOFTWARE RELIABILITY - MEASURES AND EFFECTS IN FLIGHT CRITICAL DIGITAL AVIONICS SYSTEMS
WILLIAM R. DUNN (NASA, Ames Research Center; Southern Colorado, University, Moffett Field, CA) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 664-669. FAA-supported research. refs
(Contract NCC2-276; NCC2-303)

The paper discusses software reliability as it applies particularly to design and evaluation of flight-critical digital avionics systems. Measures of software reliability, measurement methods and reliability (macro-) models are discussed. Recent work assessing their accuracy in predicting software errors in 'fly-by-wire' Newtonian applications is presented. Additional, detailed topics are discussed including software error distributions (e.g. catastrophic vs. noncatastrophic) and the effects of system growth/maturity on reliability improvement. In practical flight-critical digital applications, software reliability improvement is sought through use of parallel, redundant software (i.e. N-version programming) or backup software that can be invoked in the event of (primary) software failure. Achievable reliability levels are however highly sensitive to common-mode specification and programming errors. Recent data correlating these errors with net software reliability are discussed. Author

A87-31538* Carnegie-Mellon Univ., Pittsburgh, Pa.
FAULT-FREE PERFORMANCE VALIDATION OF AVIONIC MULTIPROCESSORS
EDWARD W. CZECK, FRANK E. FEATHER, ANN MARIE GRIZZAFFI, ZARY Z. SEGALL (Carnegie-Mellon University, Pittsburgh, PA), GEORGE B. FINELLI (NASA, Langley Research Center, Hampton, VA) et al. IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 670-677. refs
(Contract NAG1-190)

This paper describes the application of a portion of a validation methodology to NASA's Fault-Tolerant Multiprocessor System (FTMP) and the Software Implemented Fault-Tolerance (SIFT) computer system. The methodology entails a building block approach, starting with simple baseline experiments and building to more complex experiments. The goal of the validation methodology is to thoroughly test and characterize the performance and behavior of ultrareliable computer systems. The validation methodology presented in this paper showed that the methodology is not machine specific and can be used in lieu of life testing approaches. By applying a building block approach at the systems level, the machine complexity was broken down to manageable levels independent of system implementation. Author

A87-31542
EVALUATION OF DATA BUSSES FOR FLIGHT CRITICAL CONTROL APPLICATIONS
JOHN MCGOUGH (Allied-Signal, Inc., Bendix Flight Systems Div., Teterboro, NJ) IN: Digital Avionics Systems Conference, 7th, Fort Worth, TX, Oct. 13-16, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 718-727.

Token passing and 1553B bus access protocols are compared with respect to their ability to provide communications in flight critical control applications. A set of performance parameters, including bus access delay, were generated for this purpose. It was concluded that the token passing bus is superior to 1553B (as typicaly implemented in avionics systems). However, it was also concluded that 1553B could be implemented, without any modification to its existing protocol, to mimic the token passing bus. With an increased bandwidth to 40 MBPS and greater terminal accommodation, the resultant 1553B would then be dynamically indistinguishable from the token passing bus. The paper concludes with recommendations for bus and terminal reliability requirements commensurate with flight critical control applications. Author

A87-31550
SINGULAR PERTURBATIONS IN SYSTEMS AND CONTROL
PETAR V. KOKOTOVIC, ED. (Illinois, University, Urbana) and HASSAN K. KHALIL, ED. (Michigan State University, East Lansing) New York, IEEE Press, 1986, 502 p. No individual items are abstracted in this volume.

The application of singular-perturbation analysis to the modeling, analysis, design and control of dynamic systems is discussed in a collection of previously published papers from the period 1961-1985. Brief analytical introductions are provided, and papers are included on the mathematical background, stability and robustness, modeling of large-scale systems, linear and nonlinear optimal control, feedback control, and stochastic systems. Applications to power systems, hydroelectric power production, nuclear reactors, and powered flight are considered. T.K.

A87-31682* General Motors Research Labs., Warren, Mich.
DYNAMIC OPTIMIZATION PROBLEMS WITH BOUNDED TERMINAL CONDITIONS
A. Y. LEE (GM Research Laboratories, Warren, MI) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 52, Jan. 1987, p. 151-162. refs
(Contract NCC2-106)
Bounded terminal conditions of nonlinear optimization problems are converted to equality terminal conditions via Valentine's device. In so doing, additional unknown parameters are introduced into the problem. The transformed problems can still be easily solved using the sequential gradient-restoration algorithm (SGRA) via a simple augmentation of the unknown parameter vector pi. Three example problems with bounded terminal conditions are solved to verify this technique. Author

A87-31719
SOLVABILITY CONDITION FOR THE FUNDAMENTAL CONTROL PROBLEM [USLOVIE RAZRESHIMOSTI OSNOVNOI ZADACHI UPRAVLENIIA]
N. L. ALIEV and T. K. SIRAZETDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1986, p. 3-6. In Russian. refs
A necessary and sufficient condition is obtained for the solvability of the fundamental control problem for convex functionals specified in full normalized spaces. These conditions are then used to determine the solvability region for the problem of finding the specified control within the specified time of the long-period motion of aircraft. V.L.

A87-32117
CONTROL OPERATIONS IN ADVANCED AEROSPACE SYSTEMS
WILLIAM R. GRAHAM (R&D Associates, Marina Del Rey, CA) (IFAC, Symposium on Control of Distributed Parameter Systems, Los Angeles, CA, June 30-July 2, 1986) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Feb. 1987, p. 3-8.
Distributed parameter control systems being studied by NASA for use in advanced aerospace systems are described. A 15 m diam antenna that will be deployed in space from a 2 cu m box has 96 control cables for controlling the shape of the antenna. Appropriate near- and far-field tests are needed for tuning the shape of the antenna on-orbit. The Space Station will be dynamically stabilized, damped and pointed with a high degree of accuracy, performed to a high degree by automated systems that adapt to a growing structure. Self-diagnosis is also a necessary feature of future EVA equipment and telerobotics, the latter assuming greater importance in a Rover for exploring the surface of Mars. The concepts are being implemented in the X-29 forward swept wing aircraft, the electronics of the Hubble Space Telescope, and in studies of the national aerospaceplane. M.S.K.

A87-32231*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STABILITY ROBUSTNESS IMPROVEMENT USING CONSTRAINED OPTIMIZATION TECHNIQUES
V. MUKHOPADHYAY (NASA, Langley Research Center; Joint Institute for Advancement of Flight Sciences, Hampton, VA) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 490-496) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Mar.-Apr. 1987, p. 172-177. Previously cited in issue 22, p. 3319, Accession no. A85-45930. refs
(Contract NAG1-199)

A87-32450
A MODAL CONTROL PROCEDURE FOR MULTILOOP DIGITAL DESIGN
T. S. BALASUBRAMANIAN, M. GOWRI, and M. V. DHEKANE (Indian Space Research Organisation, Vikram Sarabhai Space Centre, Trivandrum, India) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1291-1295. refs
A systematic procedure is drawn here to apply modal control theory to the design of multiaxis autopilots. Sequential application of a single input eigenvalue assignment algorithm to the multi-input discrete model leads to the state feedback controller design. The controller so obtained is condensed into a set of coupled recursive filters by reckoning the modes needed for feedback and relating them to the measurement. An aircraft model has been adopted for illustration of this procedure. Author

A87-32463
THE PRINCIPLES OF COMPOSITE OPTIMUM DESIGN OF COMPOUND AGGREGATE COMPLEXES
I. A. LAZAREV (Moskovskii Energeticheskii Institut, Moscow, USSR) IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 . Tokyo, AGNE Publishing, Inc., 1986, p. 1385-1390.
The problem of coordination of design decisions under cooperative development of compound technical complexes (a problem which is most acute in the cooperative design of aircraft) is considered, and an approach consisting of a cooperatively designed complex with performance required from the elements of an available and problem-oriented developing aggregate base, is described. An optimum spatial-structural-parametric organization of the developing complex under the conditions of an open system variety of the possible interlevel project decisions is provided. R.R.

A87-33249
ADAPTIVE METHODS FOR CONTROL SYSTEM DESIGN
MADAN M. GUPTA, ED. (Saskatchewan, University, Saskatoon, Canada) and CHI-HAU CHEN, ED. (Southeastern Massachusetts University, North Dartmouth, MA) New York, IEEE Press, 1986, 480 p. No individual items are abstracted in this volume.
A collection of reprint papers is presented which covers the adaptive methods in feedback control systems that have been developed over the past two decades. Historical perspectives and surveys on adaptive control are given, and the theory for the design of model reference adaptive systems and self-tuning regulators is discussed. Adaptive control of uncertain plants using dual control and related approaches is covered. The applications to aircraft control problems, adaptive autopilots, and process control, robotics, and other fields are addressed. C.D.

A87-33612#
APPLICATION OF A DYNAMIC OPTIMIZATION PACKAGE
W. G. C. COBB, A. W. WAKELING, and P. WARD (Structural Dynamics Research Corp., Hitchin, England) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 518-524. refs
(AIAA PAPER 87-0825)
Structural optimization techniques demonstrated for general statics problems are presently extended to frequency constraints, in order to facilitate the design of complex structures subject to dynamic loading in an automated manner. In addition to obtaining a degree of mass reduction by these means, deeper insight is gained into the behavior of these structures, leading in turn to superior design concepts. A user-friendly interactive program closely integrated with preprocessing and postprocessing software is employed. O.C.

A87-33614*# University of Western Michigan, Kalamazoo.
OPTIMIZATION AND ANALYSIS OF GAS TURBINE ENGINE BLADES
D. J. VANDENBRINK (Western Michigan University, Kalamazoo, MI) and D. A. HOPKINS (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 535-537. refs
(AIAA PAPER 87-0827)

A gas turbine engine blade design is optimized using STAEBL. To validate the STAEBL analysis, the optimized blade design is analyzed using MARC, MHOST and BEST3D. The results show good agreement between STAEBL, MARC, and MHOST. The conclusion is that STAEBL can be used to optimize an engine blade design. Author

A87-33620#
KNOWLEDGE-BASED (EXPERT) SYSTEMS FOR STRUCTURAL ANALYSIS AND DESIGN
LARRY R. FELT, ANDREW F. GRISHAM, and BENNIE F. DOTSON (Boeing Military Airplane Co., Seattle, WA) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 601-610. refs
(AIAA PAPER 87-0836)

Fourteen years ago the Boeing Company began the development of an interfaced, modular, knowledge-based structural analysis system which would serve as a rapid, efficient and accurate design and analysis tool. This paper describes specific details of the resulting Interfaced Structural Analysis System (ISAS) and presents examples of its usage within the Boeing Company. Specific applications in the multidisciplinary/structural optimization and aeroelastic tailoring fields are included. Future directions and current modifications, such as, the use of microcomputers in a work station environment, are also presented. Author

A87-35009#
AIRCRAFT AVAILABILITY OPTIMIZATION
A. KNOLL (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 54-59. refs

A method of integrated optimization is presented for an aircraft system, subject to reliability, weight and life cycle cost limiting constraints and subject to data uncertainties. Aircraft availability is used as the system performance object function and the optimization is a combination of a heuristic iterative method, searching among ranked components (ranking evaluated by calculus of variations) and taking into consideration data uncertainty probabilities (stochastic programming). Time dependent aircraft and component availabilities and costs are evaluated, including maintenance and spare parts logistic alternatives, from which critical periods are identified, along with their respective critical components. The optimization method is illustrated by a sample problem. Author

A87-35029#
COMPUTER AIDED DESIGN OF AERONAUTICAL STRUCTURES MADE OF COMPOSITE MATERIALS
S. GALI, Y. MOSHE, N. NAGGAR, N. HESKIA, and R. REUVENI (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers . Haifa, Technion Israel Institute of Technology, 1986, p. 251-256.

A system for computer-aided designing of aeronautical structures composed of composite materials is proposed. The system is to provide the graphical and numerical means to display, evaluate, and analyze design structures. The system consists of: information, geometry, design operations, production operations, and management modules. The functions of these modules and the operation of the system are described. I.F.

N87-20201# Aircraft Research Association Ltd., Bedford (England).
A DISCUSSION ON A MESH GENERATION TECHNIQUE APPLICABLE TO COMPLEX GEOMETRIES
N. P. WEATHERILL, J. A. SHAW, C. R. FORSEY, and K. E. ROSE *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986 Sponsored by Ministry of Defence and British Aerospace
Avail: NTIS HC A19/MF A01

A general three-dimensional block structured grid generation technique is described. It was coupled with an Euler algorithm to simulate the flow around complicated aerodynamic configurations. The flow field is subdivided into a set of non-overlapping blocks and grids are generated simultaneously in all of the blocks using an elliptic grid generation method. Appropriate boundary conditions applied on the face of the blocks ensure that grid lines pass smoothly between blocks leaving the grid globally smooth. Details of the surface and field grid generation are given and techniques to control the position of grid points are highlighted. Grid topologies for complicated civil and military configurations are discussed. Examples are given of grids for complicated configurations and some results of flow calculations on block structured grids are shown. Author

N87-20202# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Theoretical Aerodynamic Group.
NUMERICAL GRID GENERATION AROUND COMPLETE AIRCRAFT CONFIGURATIONS
WILLY FRITZ *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 8 p Nov. 1986
Avail: NTIS HC A19/MF A01

A method for accurately generating boundary conforming, three-dimensional computational grids applicable to realistic aircraft configurations is presented. Configurations with an arbitrarily shaped and positioned wing, a horizontal tail (or canard) and a vertical tail attached to an arbitrarily shaped fuselage can be treated. The grid generation technique divides the computational domain into multiple rectangular blocks whose structure follow the natural lines of the configuration. For each of these contiguous sub-regions the grids are generated separately and then patched together to cover the entire physical region. The grids for the sub-regions are generated by the solution of elliptical partial differential equations (PDE). The method is an automated procedure but with interactive control and optimization possibilities which enable the user to produce coordinate lines with sufficient continuity across the block boundaries. Due to the block structure and the data organization of the method very fine grids (up to several millions of grid points) for complete aircraft configurations can be generated. Author

N87-20203*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
GEOMETRY DEFINITION AND GRID GENERATION FOR A COMPLETE FIGHTER AIRCRAFT
THOMAS A. EDWARDS *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 12 p Nov. 1986 Previously announced as N86-28050
Avail: NTIS HC A19/MF A01 CSCL 09B

Recent advances in computing power and numerical solution procedures have enabled computational fluid dynamicists to attempt increasingly difficult problems. In particular, efforts are focusing on computations of complex three-dimensional flow fields about realistic aerodynamic bodies. To perform such computations, a very accurate and detailed description of the surface geometry must be provided, and a three-dimensional grid must be generated in the space around the body. The geometry must be supplied in a format compatible with the grid generation requirements, and must be verified to be free of inconsistencies. A procedure for performing the geometry definition of a fighter aircraft that makes use of a commercial computer-aided design/computer-aided manufacturing system is presented. Furthermore, visual representations of the geometry are generated using a computer graphics system for verification of the body definition. Finally, the

three-dimensional grids for fighter-like aircraft are generated by means of an efficient new parabolic grid generation method. This method exhibits good control of grid quality. Author

N87-20204# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

AN ASSESSMENT OF THE USE OF LOW-ORDER PANEL METHODS FOR THE CALCULATION OF SUPERSONIC FLOWS

J. S. SMITH and D. S. WOODWARD *In* AGARD Applications of Computational Fluid Dynamics in Aeronautics 8 p Nov. 1986

Avail: NTIS HC A19/MF A01

Three low-order panel methods developed for the analysis of supersonic flows were used to make calculations for a number of test configurations, with the aim of establishing the range of problems for which this class of computational method yields adequate solutions. The programs investigated were the Woodward USSAERO/C program, the related NLRAERO program, and the British Aerospace Warton supersonic panel program. Results obtained using these programs were evaluated against theoretical and experimental data for a number of test cases covering wing-alone, body-alone and wing-body geometries. It is concluded that low-order panel methods can provide adequate solutions for supersonic flows about wings, bodies and wing-body combinations, provided the assumptions implicit in the linearised potential flow model are not violated. Examples show that the prediction of lift and pitching moment curve slopes for quite complex configurations may be acceptable, but that the detailed pressure distributions are not always predicted satisfactorily. In particular, serious problems are encountered in calculating the flow about wings with rounded supersonic leading edges due to the linearised flow model which is used. Author

N87-21603# Massachusetts Inst. of Tech., Cambridge. Lincoln Lab.

A COORDINATE CONVERSION ALGORITHM FOR MULTISENSOR DATA PROCESSING

ERIC M. SHANK 5 Aug. 1986 46 p

(Contract DTFA01-84-Z-2-02030)

(AD-A176368; ATC-139; DOT/FAA/PM-86-37) Avail: NTIS HC A03/MF A01 CSCL 17I

Processing of aircraft surveillance data form several geographically separated radars is most easily accomplished using a common coordinate system to represent data from all sensors. The Multisensor Data Processing system currently being developed for the FAA in support of the Advanced Automation System (AAS) requires a degree of accuracy and consistency that is not available from the current implementation of coordinate conversion. A study has been undertaken to design a coordinate conversion algorithm that meets the needs of Multisensor Data Processing. The process of projection of the ellipsoidal surface of the Earth onto a planar surface is examined in light of the requirements of air traffic control systems. The effects of the non-sperical nature of the Earth and of limited computational resources are considered. Several standard cartographic projection techniques are examined, and the stereographic projection is found to be the projection of choice. A specific implementation of stereographic projection that meets the needs of Multisensor Data Processing is described. This implementation makes use of several approximations to decrease the computational load. The systematic errors introduced by these approximations are removed by the addition of a correction term determined from the precomputed error surface. GRA

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A87-33720#

A FIVE YEAR REVIEW ON DFVLR HELICOPTER/ROTOR ACOUSTICS RESEARCH

H. H. HELLER, W. R. SPLETTSTOESSER, and K.-J. SCHULTZ (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B . New York, American Institute of Aeronautics and Astronautics, 1987, p. 674-688. refs

(AIAA PAPER 87-0912)

Recent German Aerospace Research Establishment activities in two areas of research are reviewed: research in support of the ICAO Committee of Aircraft Noise to establish and improve helicopter noise certification standards and recommended practices; and research into the aeroacoustic mechanisms of rotor noise. In the ICAO-initiated flight tests, the sensitivity of helicopter noise to flight-height, helicopter mass, and flight speed and/or advancing blade tip Mach number was determined. Helicopter impulsive noise was studied in the German Dutch Wind Tunnel using a U.S.-Army model main rotor. Preliminary results of isolated tail rotor tests and main-rotor/tail-rotor interaction tests are also reported. R.R.

N87-20277*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THEORETICAL KINETIC COMPUTATIONS IN COMPLEX REACTING SYSTEMS

DAVID A. BITTKER *In its* NASA-Chinese Aeronautical Establishment (CAE) Symposium p 175-189 1986

Avail: NTIS HC A01/MF A01 CSCL 20M

Nasa Lewis' studies of complex reacting systems at high temperature are discussed. The changes which occur are the result of many different chemical reactions occurring at the same time. Both an experimental and a theoretical approach are needed to fully understand what happens in these systems. The latter approach is discussed. The differential equations which describe the chemical and thermodynamic changes are given. Their solution by numerical techniques using a detailed chemical mechanism is described. Several different comparisons of computed results with experimental measurements are also given. These include the computation of (1) species concentration profiles in batch and flow reactions, (2) rocket performance in nozzle expansions, and (3) pressure versus time profiles in hydrocarbon ignition processes. The examples illustrate the use of detailed kinetic computations to elucidate a chemical mechanism and to compute practical quantities such as rocket performance, ignition delay times, and ignition lengths in flow processes. Author

N87-20601# Air Force Systems Command, Wright-Patterson AFB, Ohio.

SUPERSONIC FLOW INDUCED CAVITY ACOUSTICS

LEONARD L. SHAW *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 2: Modal Test and Analysis, Testing Techniques, Machinery Dynamics, Isolation and Damping, Structural Dynamics p 209-216 Aug. 1986

Avail: NTIS HC A10/MF A01 CSCL 20K

A wind tunnel test was performed on a cavity model with variable length and depth. It was tested at three supersonic Mach numbers of 1.5, 2.16 and 2.86. Four unit Reynolds numbers, 1.0, 2.0, 3.0, 4.0 million were tested. The model was tested at two angles of attack and two yaw angles. Two cavity widths were tested. Acoustic data were obtained for almost all combinations of the test

parameters. Strong acoustic resonance was obtained for many of the configurations and all three Mach numbers. Levels as high as 165 dB were measured. Reynolds number was shown to strongly affect excitation of specific resonant modes. Angle of attack affected the levels as well as yaw. An important result of the effort is the affect of model scale. It was shown that by changing the cavity size, but keeping all other parameters equal, change in the flow induced acoustic levels as large as 20 dB can occur. As much of the acoustic data as possible is documented so that the data trends will be available for the user. Author

N87-20797*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AIRCRAFT NOISE SYNTHESIS SYSTEM: VERSION 4 USER INSTRUCTIONS

DAVID A. MCCURDY, BRENDA M. SULLIVAN (Bionetics Corp., Hampton, Va.), and ROBERT E. GRANDLE Feb. 1987 31 p (NASA-TM-89089; NAS 1.15:89089) Avail: NTIS HC A03/MF A01 CSCL 20A

A modified version of the Aircraft Noise Synthesis System with improved directivity and tonal content modeling has been developed. The synthesis system is used to provide test stimuli for studies of community annoyance to aircraft flyover noise. The computer-based system generates realistic, time-varying audio simulations of aircraft flyover noise at a specified observer location on the ground. The synthesis takes into account the time-varying aircraft position relative to the observer; specified reference spectra consisting of broadband, narrowband, and pure tone components; directivity patterns; Doppler shift; atmospheric effects; and ground effects. These parameters can be specified and controlled in such a way as to generate stimuli in which certain noise characteristics such as duration or tonal content are independently varied while the remaining characteristics such as broadband content are held constant. The modified version of the system provides improved modeling of noise directivity patterns and an increased number of pure tone components. User instructions for the modified version of the synthesis system are provided. Author

N87-20799# Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.

THE 1985 SMALL PROPELLER-DRIVEN AIRCRAFT NOISE TEST PROGRAM

KENNETH E. JONES Oct. 1985 41 p (AD-A175596; DOT/FAA/EE-85-8) Avail: NTIS HC A03/MF A01 CSCL 20A

The international aviation community is currently reviewing noise certification procedure for small propeller-driven aircraft. Under discussion is a proposal to substitute a ground-plane microphone for the currently specified elevated microphone as a means of suppressing spectral irregularities. Given the strong low and mid-range tonal frequencies attendent to propeller-driven aircraft, the constructive/destructive interference pattern in an aircraft frequency spectrum can result in inconsistent certification test results for aircraft with different blade passage frequencies. The Federal Aviation Administration conducted flight tests during the summer of 1985 to compare noise levels measured at four feet to ground-plane levels as a function of the blade passage frequency. A preliminary assessment of the data acquired during the flight tests is presented. A more comprehensive analysis of the test results will be documented in the final report. Three flight tests were performed using a Cessna 210, Cessna Caravan I, and a (Beechcraft) U.S. NAVY T-34C. A vertical array (3.75 to 7.0 ft.) of microphones and a range of test RPMs were used to test the theoretical prediction of the ground reinforcement effect. As a secondary objective, the microphones were redeployed in horizontal arrays to test for a difference in variability between elevated and ground-plane microphones. DOE

N87-20800# European Space Agency, Paris (France).

NOISE MEASUREMENTS ON THE HELICOPTER BK 117 DESIGN. WEIGHTED NOISE LEVELS AND INFLUENCE OF AIRSPEED

WOLF R. SPLETTSTOESSER, KLAUS P. ANDERS, and KARL-HEINZ SPIEGEL Nov. 1986 90 p Transl. into ENGLISH of "Schallmessungen an der Hubschraubernewentwicklung BK 117 - Bewertete Laermpegel und Einfluss der Fluggeschwindigkett" DFVLR, Brunswick, West Germany, report DFVLR-Mitt-81-18, 1981 Original language document was announced as N8219957 (ESA-TT-748; DFVLR-MITT-81-18; ETN-87-99423) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, West Germany DM 22.95

Noise measurements on the prototype helicopter BK 117 were performed in strict compliance with the proposed international Civil Aviation Organization regulations for noise certification of helicopters. Measurement procedure, noise data acquisition, analysis and reduction as well as applied correction procedures are described. Effective perceived noise levels (EPNL) and other noise descriptors were evaluated and related to the proposed noise limits. Additional level flyover tests with variable airspeed were conducted to investigate the resulting effect on the EPNL and other noise measures. ESA

N87-21652* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ACOUSTIC GUIDE FOR NOISE-TRANSMISSION TESTING OF AIRCRAFT Patent

RIMAS VAICAITIS, inventor (to NASA) (Columbia Univ., New York) 24 Feb. 1987 9 p Filed 3 Jul. 1985 Supersedes N86-30086 (24 - 10, p 1663)
(NASA-CASE-LAR-13111-1-CU; US-PATENT-4,644,794; US-PATENT-APPL-SN-751695; US-PATENT-CLASS-73-583; US-PATENT-CLASS-73-589; US-PATENT-CLASS-73-599) Avail: US Patent and Trademark Office CSCL 20A

Selective testing of aircraft or other vehicular components without requiring disassembly of the vehicle or components was accomplished by using a portable guide apparatus. The device consists of a broadband noise source, a guide to direct the acoustic energy, soft sealing insulation to seal the guide to the noise source and to the vehicle component, and noise measurement microphones, both outside the vehicle at the acoustic guide output and inside the vehicle to receive attenuated sound. By directing acoustic energy only to selected components of a vehicle via the acoustic guide, it is possible to test a specific component, such as a door or window, without picking up extraneous noise which may be transmitted to the vehicle interior through other components or structure. This effect is achieved because no acoustic energy strikes the vehicle exterior except at the selected component. Also, since the test component remains attached to the vehicle, component dynamics with vehicle frame are not altered.

Official Gazette of the U.S. Patent and Trademark Office

N87-21657# National Aerospace Lab., Amsterdam (Netherlands). Structures Dept.

SOME ASPECTS OF FAN NOISE GENERATION IN AXIAL COMPRESSORS

J. B. H. M. SCHULTEN Dec. 1985 21 p In DUTCH; ENGLISH summary Presented at the Dutch Acoustic Society on Flow Noise, Utrecht, The Netherlands, 11 Sep. 1985
(NLR-MP-85089-U; ETN-87-99299) Avail: NTIS HC A02/MF A01

Sound generation by the interaction of velocity disturbances and stator vanes was theoretically investigated using a lifting surface approach. In this model the effect of vane lean on the sound field generated by a typical stator exposed to the disturbances of the viscous wake system of a rotor were considered. It is found that, in contrast to earlier speculations, even a moderate amount of vane lean increases the acoustic power considerably. It is shown that, at frequencies prevailing in current turbofans, even a small vane stagger angle significantly affects the sound generation process. The physical origin of both phenomena is discussed. ESA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

A87-32002
THE CURRENT STATUS OF THE WARSAW CONVENTION AND SUBSEQUENT PROTOCOLS IN LEADING ASIAN COUNTRIES
TAE HEE LEE Air Law (ISSN 0165-2079), vol. 11, Dec. 1986, p. 242-247.

The application and interpretation of the 'Warsaw System' in Asian countries, in particular Japan and the Republic of Korea, are examined. The Warsaw System is composed of the Warsaw Convention of 1929, the Hague Protocol of 1955, the Guadalajara Convention of 1961, the Guatemala City Protocol of 1971, and the Montreal Additional Protocols Nos. 1, 2, 3, and 4 of 1975. The application of the Warsaw Convention to one-way air transportation between states which are parties to different agreements in the Warsaw System is studied. Examples of aviation litigation in Japan and the Republic of Korea regarding liability limits, willful misconduct, and currency conversion are presented. The future of the Warsaw System in Asia, and the need to develop a unified system of rules governing international commercial air transportation are discussed. I.F.

A87-32636
AEROSPACE INFORMATION REPORT 1939 TRIAL APPLICATION
C. E. CURRY and M. D. CARPENTER (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 12 p. refs
(SAE PAPER 861787)

The proposed AIR 1939, 'Aircraft Engine Life Cycle Cost Guide', states the need for a methodology capable of relating input and output data on a consistent basis. This paper demonstrates that a methodology consistent with the proposed guidelines of AIR 1939 is practical. A generic example was constructed based on the design-to-cost/life cycle cost (DTC/LCC) requirements for an Allison engine full-scale development program. The example is presented using concepts and terminology from AIR 1939 in order to demonstrate the applicability of the document. Author

A87-32637
OVERVIEW OF AIR 1939
P. H. KUTSCHENREUTER SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. 7 p.
(SAE PAPER 861788)

The scope and application of the Aircraft Engine Life Cycle Cost Guide (AIR 1939) proposed by a Society of Automotive Engineers committee is outlined. AIR 1939 is intended for military propulsion system life cycle cost (LCC) analysis. The Guide formalizes the specifications for LCC data categories, input and output, program phasing of LCC data inputs, ground rules and assumptions, and LCC terms. Techniques for interfacing LCC analysis with design-to-cost efforts are discussed, along with extension of LCC methods to simultaneous consideration of the interaction between the engine and aircraft. Techniques are also described for ensuring coordination of LCC efforts and methodology among all participants during the development of an aircraft, its systems and the engine. M.S.K.

A87-34865
EUROPEAN ROTORCRAFT FORUM (ERF) INDEX OF ERF-PAPERS 1975-1985
C. W. DE JONG (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Vertica (ISSN 0360-5450), vol. 11, no. 1-2, 1987, p. 359-405.

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GENERAL

A87-31615#
JAPAN ADVANCES ITS AEROSPACE TIMETABLE
NEIL W. DAVIS Aerospace America (ISSN 0740-722X), vol. 25, March 1987, p. 18-22.

Economic pressures caused by the recent unprofitability of industries such as shipbuilding are encouraging large Japanese companies to accelerate the development of aerospace products. For example, Mitsubishi is increasing the information links between factories, including the Nagoya Aircraft Works which is to build the H-II launch vehicle. A common pattern is that Japanese manufacturers lease technologies from U.S. companies to build, e.g., missiles and aircraft, assimilate the technologies, improve on them, and then end the cooperative relationships. Cooperation also allows participation in large programs which Japan can not do alone, such as the Space Station and the 7J7 aircraft. An in-depth survey is provided of the involvements of specific Japanese companies in launch vehicle, satellite, semiconductor, supercomputer, aircraft and telecommunications programs. M.S.K.

A87-33152* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TRANSITION TO SPACE - A HISTORY OF 'SPACE PLANE' CONCEPTS AT LANGLEY AERONAUTICAL LABORATORY 1952-1957
JAMES R. HANSEN (NASA, Langley Resarch Center, Hampton, VA) British Interplanetary Society, Journal (Pioneering Space) (ISSN 0007-084X), vol. 40, Feb. 1987, p. 67-80. refs

The supersonic speeds of X-series aircraft and wind tunnel data in the early 1950s demonstrated that hypersonic flight was an achievable goal. A blunt-nosed vehicle was found to form a bow shock that deflected much of the heating an aircraft would otherwise experience at high speeds. It was felt that critical aspects of hypersonic flight, e.g., aerodynamic performance and heating, controllability, etc., could not be fully explored in wind tunnels. The X-15 project was initiated by NASA in 1954 to produce a vehicle capable of Mach 7 flight to altitudes that would permit short evaluations of human performance in microgravity. Design tradeoffs examined in the program are discussed, with emphasis on lifting bodies and winged vehicles with high L/D ratios. Political pressures created by the public triumph of the Sputnik in 1958 removed much of the impetus for development of a manned spaceplane, and long-term goals that eventually led to the Shuttle were delayed by a short-term program oriented toward ballistic manned capsules. M.S.K.

N87-21845# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Research Center.
ACTIVITIES REPORT IN AEROSPACE SCIENCES Annual Report, 1985
Oct. 1986 19 p Original contains color illustrations
(ETN-87-99369) Avail: NTIS HC A02/MF A01

Laminar boundary layers in a hypersonic flow; boundary manipulators; analyses of airfoil laminarity versus Reynolds number in the wind tunnel; real time shop planning; force control robot; multicyclic helicopter blade pitch control (flight performance of the stochastic adaptive regulator); artificial intelligence and software

engineering; acoustic intensimetry; radar measurement systems; evaluation of the electrical quality of GaAs field effect transistors; and ceramic composite SiC fiber coatings are discussed. ESA

SUBJECT INDEX

Typical Subject Index Listing

SUBJECT HEADING

AERODYNAMIC BALANCE
Low speed rotary aerodynamics of F-18 configuration for 0 deg to 90 deg angle of attack: Test results and analysis
[NASA-CR-3608] p 15 N87-10836

TITLE | REPORT NUMBER | PAGE NUMBER | NASA ACCESSION NUMBER

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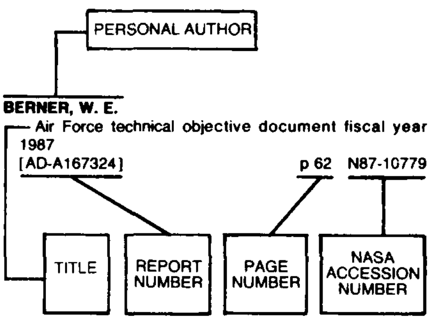

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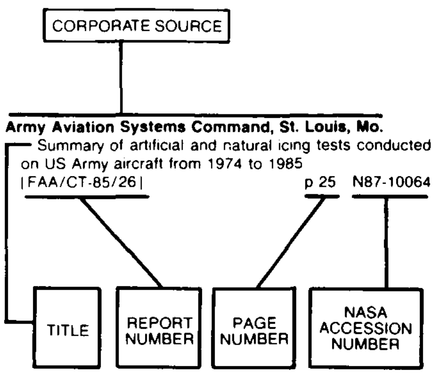

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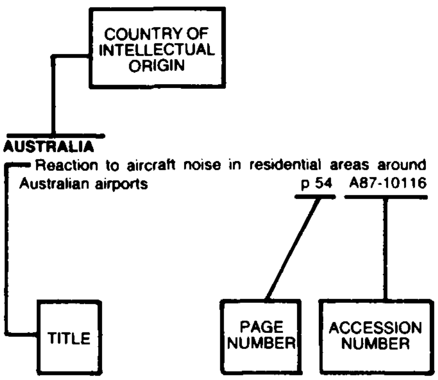

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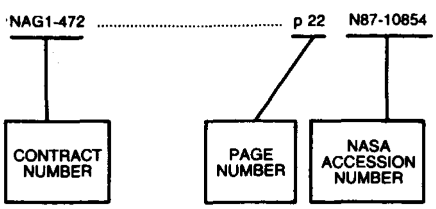

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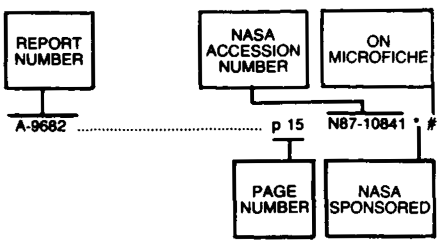

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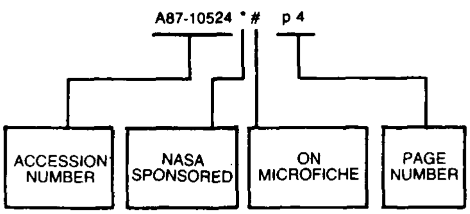

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